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FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION, ALEXANDRIA, VIRGINIA

64-7

FINAL REPORT

DETECTION OF HUMANS

IN

CONCEALED PREPARED POSITIONS

Prepared for
Limited War Laboratory
Aberdeen Proving Ground

THE BIOSEARCH COMPANY

BOSTON, MASSACHUSETTS

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OUTLINE OF CONTENTS

A. PREFACE

This report was prepared in accordance with the requirements of United States Army Contract DA-019-AMC-0122-R, and with the approval of the U. S. Army Limited War Laboratories, Aberdeen. Md.

Dr. Max Krauss, Chief of Biological Research at the Limited War Laboratories, has been the Technical Project Monitor for this work. Mr. Stephan Fedak, Deputy Chief, R&D Branch, Boston Army Procurement District, was the Contracting Officer's Representative and also provided liaison with the Army Procurement Office at Aberdeen, Md.

The technical analyses were done by an interdisciplinary group, with participants in physics, chemistry, biology, medicine, biophysics, and various engineering disciplines. This report was written by Dr. Alfred T. Kornfield.

Grateful acknowledgment is expressed for the special assistance provided by Mr. Fedak and the Boston Procurement District staff, for the technical counsel and aid of Dr. Krauss and personnel at the Limited War Laboratories, and to all of the Biosearch Co. professional and technical personnel who contributed so ably to this report.

THE BIOSEARCH CO. BOSTON.

Dr. A. T. Kornfield, President.

B. INTRODUCTION

To examine the capabilities of biosensing techniques for the detection of humans in concealed positions, this study concerned itself with a review of the diverse attributes of man yielding signals, the signal modifications in environment, and various sensing concepts.

About 2000 references are cited, selected from an aggregate of about 8000 with the balance rejected as irrelevant or of no value. Resources used included over 30 document and book collections;the Harvard Libraries(the medical and Cambridge complexes); MIT group; Boston Medical; Boston Public; Boston Univ; Tufts Medical; New York Public; ASTIA(DDC)reprints and their NY regional center film collection;QMR&E Library, Natick; Army Chemical Lab Library, Edgewood;Air Force Cambridge Res Lab. Library.

In considering human signal sources and attributes, emphasis was placed on assembly of a catalog of chemical substances excreted through all body portals;for comparative analysis, other human physical attributes and signals were set down(emission, reflection, proximity properties), resulting in an inventory of most of the major signals produced by man

Environmental modification of chemical signals from man, by substances from plants and animals, weather effects, etc;was augmented also by comparative data on effects of environment on physical signal transmission.

Sensing techniques examined highlight biosensing(defined as the use of living material as transducer or pickup, in isolated form, for chemical or physical signals, analogous with physical sensor devices. A large aggregrate of possibilities is presented for consideration, emphasizing chemosensing, which offers the most potential of all of the biosensors for the major problem solution. The plausibility of the biosensing concept must rest on evidence presented, of ability to maintain material alive, to conveniently gather reproducible input/output data from it, and to find performance properties superior to physical or chemical sensing. Comparative data on chemical and physical sensing of chemical substances and physical phenomena is presented.

From the short effort completed, three things have resulted. One is this report, serving as a source book, aiding the reader in going further in exploring in depth any concept cited, and in further analysis of complete detection systems of biological, chemical, or physical nature, as grounded in known human properties. The second result is the series of recommendations for further work, based on the findings in the study, suggesting experiments on promising techniques, particularly on biosensing, also reviews and analyses to make up for data deficiencies uncovered in the literature. The third result is the provision of an "idea"book here, with a variety of speculative possibilities presented, for detection, but set off clearly from those documented concepts stated.

Pursuit of a more thorough analysis across the span of all of the areas presented would be desirable, highlighting the promising areas set forth in the recommendations;this could aid in bringing the Limited War Laboratory effort more rapidly towards the goal of a suitable field detection instrument for concealed humans.

C. HUMAN ATTRIBUTES AND CONTRASTS

I. Chemical Products.

On the following pages will be found a list of major chemical substances excreted in urine, in feces, and from the skin. These are readily traceable to sources of quantitative data for each substance, permitting the reader to go further in analysis of detection of concealed humans by chemical products emitted.

In addition to the list, supplementary data and comments follow, on skin products(sweat, sebum, etc.), their alteration by skin bacterial action, the attraction of animals by their odors; also provided are additional data on urine products, g.i. tract excretions, and expired air.

Ethnic and regional comparisons of these products are presented, and regional diet and nutritional data source information is cited. Notes on related closed-cabin-ecology studies and on human tissue chemical composition are given.

a. List of Major Chemical Substances Produced by Man..

The tables which follow have the following features: the first section lists over 400 specific chemical substances of low molecular weight, produced as indicated from one or several of the three body channels as feces, urine, or skin products(from eccrine, apocrine, sebaceous glands, etc.). The short second section contains a mixed collection of hormones, enzymes, other high molecular weight substances, etc. The third section lists the references from which can be obtained quantitative data on each substance measured, from the body channel indicated.

To Use the Tables:

Note that each specific chemical name is accompanied by symbols indicating the body excretory channel, and reference codes to be looked up in the reference list in the third section.

Example: Alanine, total...... S-AG, U-12HBU.(taken from Table).
S-AG= Sweat or Skin, (in reference AG).
U-12HBU=Urine, (in references 1, 2, H, B, U).
Turn to third section of table, note that code AG cites page 223 of (Kuno-56)listed in biblio at end of report; #1 cites page 363 of (Altman-61), etc.

CHEMICAL SUBSTANCES EXCRETED BY MAN

Section 1. Specific Substances of Low Molecular Weight

ACETIC ACID	S-AC,
ACETOACETIC ACID	U-12
ACETONE FREE	U-12E
ACONITIC ACID	U-2
ADENINE	U-12
ADIPIC ACID	U-2
ADIPIC ACID ALPHA AMINO	U-2
ADRENALIN	U-2B
ALANINE CONJUGATED	U-2
ALANINE TOTAL	S-AG, U-12HBU
ALANINE BETA	U-2U
ALDOSTERONE	U-1
ALLANTOIN	U-12BHJ,AA,AC
ALUMINUM	F-5Y U-12FH,AC
AMINES PRIMARY	U-2
AMINES AROMATIC FRACTION	U-2
AMINO ACIDS FREE	U-AA,AC
AMINO ACIDS TOTAL	S-6BKLSTV,AG U-1BHJ,AA
AMINOLEVULIC ACID	U-H
AMINO SUGARS	U-H
AMMONIA	S-67BLTV,AG F-5BFZ U-12BFH,AA,AC
ANDROGENS MALE	U-1
ANDROGENS FEMALE	U-1
ANDROSTERONE	U-1
ANSERINE	U-2
ANTHRANILIC ACID	U-2
ARABINOSE	U-2
ARGININE FREE	U-BH
ARGININE COMBINED	U-2B
ARGININE TOTAL	S-6BL,AG F-5BR U-12BHU,AB,AC
ARSENIC	S-F F-5AF U-1F
ASCORBIC ACID	S-6DLV,AE,AG F-5D U-12D,AC
ASCORBIC ACID DEHYDRO	S-3,AG U-2
ASPARAGINE	U-2U
ASPARTIC ACID FREE	U-1BH
ASPARTIC ACID COMBINED	U-2B
ASPARTIC ACID TOTAL	S-AG U-12BHU,AB
BENZOIC ACID, PARA-AMINO	S-3LD,AG F-59D U-125D
BENZOIC ACID, META-HYDROXY	U-2
BENZOIC ACID, PARA-HYDROXY	U-2
BENZOIC ACID THREE-METHOXY-FOUR-HYDROXY	U-2
BERYLLIUM	U-2
BICARBONATE	U-2
BILIRUBIN	S-E U-15EH
BIOTIN	S-6DL F-9DS U-12D,AC
BISMUTH	S-V
BROMINE	S-V,AG U-12F
BUTYRIC ACID, ALPHA-AMINO	U-2
BUTYRIC ACID, AMINO	U-U
BUTYRIC ACID, AMINO-ISO	U-2
CALCIUM	S-67FLTSV,AG F-5AGXZ U-125FHJX,AC
CAPROIC ACID	S-AE,
CAPROIC ACID, ALPHA-KETO-ISO	U-2

CAPRYLIC ACID	S-AE,
CARBONIC ACID	F-NW U-1
CARBOXAMIDE, N-METHYL-TWO-PYRIDONE-FIVE-	U-2
CARNATINE	U2
CARNOSINE	U-2
CAROTENES	F-5D U-5
CATECHOLAMINES	U-2
CATHEPSIN	U-2
CHLORIDE	S-67FLS,AG F-5AFGXZ U-12FHJX,AC
CHOLESTEROL TOTAL	S-4CKMST,AG F-5C U-12CH,AC
CHOLESTEROL DEHYDRO	S-4
CHOLESTEROL ESTERS	S-4,AG
CHOLINE	S-6DLTV U-12DH,AC
CINNAMIC ACID, PARA-HYDROXY-	U-2
CINNAMIC ACID THREE-METHOXY-FOUR-HYDROXY	U-2
CINNAMOYL-GLYCINE, PARA-HYDROXY-	U-2
CITRIC ACID	S-AE, U-12EH,AC
CITRULLINE FREE	U-5B
CITRULLINE COMBINED	U-B
CITRULLINE TOTAL	U-125BV
COBALAMIN	U-1D
COBALT	F-5F U-2FS
COPPER	S-37TV,AG F-5AFY U-125FH,AC
COPROPORPHYRINS	U-1EH
CORTICOIDS	S-3
CREATINE	S-L,AG U-12BH,AC
CREATININE	S-37BKLSTV,AG U-12BHJ,AA,AC
CRESOL,PARA	F-R U-2
CYSTEINE	U-U
CYSTINE FREE	U-1BH
CYSTINE COMBINED	U-2B
CYSTINE TOTAL	S-AG, U-12BHU,AB,AC
DIKETOGLUCONIC ACID	U-12
ERGOTHIONINE	U-2
ERGOTHIONINE, CONJUGATED	U-2
ESTRADIOL	U-12
ESTRIOL	U-1
ESTRONE	U-12
ETHANOLAMINE	U-2H
FAT NEUTRAL	F-5CZ
FAT UNSAPONIFIABLE	F-5C
FAT TOTAL	S-AG, F-5ACGZ
FATTY ACIDS FREE	S-48CS F-5CGZ,AF U-H
FATTY ACIDS HYDROXY	S-8
FATTY ACIDS UNSATURATED	S-C
FATTY ACID ESTERS	S-TK
FATTY ACIDS COMBINED TOTAL	S-M F-G,AF
FATTY ACIDS TOTAL	S-8T F-5C
FERULIC ACID	U-2
FERULIC ACID, DIHYDRO	U-2
FLAVINES	U-2
FRUCTOSE	U-2
FOLIC ACID GROUP	S-3DLTV F-59D U-12D,AC
FORMIC ACID	U-12E
FLUORINE	S-V U-12F,AC

GALACTOSE	U-2
GLUCOSE	S-37EKSTV,AG U-25EH
GLUCURONIC ACID	U-2H
GLUTAMINE	S-AG, U-2HU
GLUTAMINE, PHENYLACETYL-	U-2
GLUTAMIC ACID, FREE	U-1BH
GLUTAMIC ACID COMBINED	U-2B
GLUTAMIC ACID TOTAL	S-AG, U-12BH,AB
GLUTARIC ACID	U-2
GLUTARIC ACID, ALPHA-OXO-	U-2
GLYCERIC ACID	U-2
GLYCERIMIDES	U-AD,
GLYCINE FREE	U-125BHU
GLYCINE TOTAL	S-AG, U-15BH
GLYCOCYAMINE	U-2,AA
GLYCOLLIC ACID	U-2
GLYOXYLIC ACID	U-2
GUANIDINE	U-H
GUANIDINOACETIF ACID	U-1H
GUANINE	U-12
GUANINE, N-METHYL-	U-12
GUANINE, ONE-METHYL-	U-2
GUANINE, SEVEN-METHYL-	U-12
GUANINE, EIGHT-OH-SEVEN-METHYL	U-12
HIPPURIC ACID	U-12BHJ,AA,AC
HIPPURIC ACID, ORTHO-AMINO-	U-2
HIPPURIC ACID, ORTHO-HYDROXY-	U-2
HIPPURIC ACID, META-HYDROXY-	U-2
HIPPURIC ACID, PARA-HYDROXY-	U-2
HISTAMINE	S-T,AG F-Z U-12
HISTAMINE, N-ACETYL-	U-2
HISTAMINE, THREE-METHYL-	U-2
HISTAMINE, ONE,THREE-DIMETHYL-	U-2
HISTAMINE, ONE-METHYL-	U-2
HISTIDINE FREE	U-1BH
HISTIDINE COMBINED	U-2B
HISTIDINE TOTAL	S-3BLV,AG F-5BR U-12BHU,AB
HISTIDINE, ONE-METHYL-	U-2U
HISTIDINE, THREE-METHYL-	U-2
HISTIDINE, METHYL-, CONJUGATED	U-2
HOMOGENTISIC ACID	U-H
HYDROCORTISONE, TETRA	U-1
HYDROGEN	F-NW
HYDROGEN SULFIDE	F-NR
HYDROXYPROLINE FREE	U-BH
HYDROXYPROLINE COMBINED	U-B
HYDROXYPROLINE TOTAL	U-BH
HYDROXYTYRAMINE	U-5
HYPOXANTHINE	U-1
HYPOXANTHINE, ONE-METHYL-	U-1
IMIDAZOLE DERIVATIVES	F-5B U-1BH,AA,AC
IMIDAZOLE-FOUR-ACETIC ACID	U-2
IMIDAZOLE-ACETIC ACID	U-2
IMIDAZOLE ACETIC ACID, ONE-METHYL-	U-2
IMIDAZOLE-ACETIC ACID, THREE-METHYL	U-2
IMIDAZOLECARBOXAMIDE, FIVE-AMINO-FOUR-	U-2

INDICAN	U-125BHJ,AA,AC
INDIGOTIN	U-H
INDOLE	F-R
INDOLE-ACETAMIDE	U-2
INDOLE ACETIC ACID	U-E
INDOLE ACETIC ACID, METHYL ESTER	U-2
INDOLE-ACETIC ACID, THREE-HYDROXY-	U-2
INDOLE ACETIC ACID, FIVE-HYDROXY-	U-2
INDOLE-ACETYLGLUTAMIC ACID	U-2
INDOLE-ACETYLGLUTAMINE	U-2
INDOLE-ACRYLIC ACID	U-2
INDOLE-THREE-CARBOXYLIC ACID	U-2
INDOLE LACTIC ACID	U-2
INOSITOL	S-6DLV,AG U-125DH
IODINE	S-37FLV,AG U-12FH,AC
IRON	S-37LTV,AG F-5AF U-125FH,AC
KETOSTEROIDS	U-AC,
KYNURENIC ACID	U-2
KYNURENINE	U-2H
KYNURENINE, N-ACETYL-	U-2
KYNURENINE, THREE-HYDROXY-	U-2
LACTIC ACID	S-6EKLSTV,AE,AG U-12EH
LACTOSE	U-2
LEVULIC ACID, DELTA-AMINO	U-2
LEAD	F-5AFGXYZ U-125FX,AC
LEUCINE FREE	U-1BH
LEUCINE COMBINED	U-2B
LEUCINE TOTAL	S-6BL,AG F-5BR U-12BHU,AB
LEUCINE, ISO, FREE	S-6 U-1BH
LEUCINE, ISO, COMBINED	U-2B
LEUCINE, ISO, TOTAL	S-L,AG F-5BR U-12BHU,AB
LIPIDS	U-H
LYSINE FREE	U-1BH
LYSINE COMBINED	U-2B
LYSINE TOTAL	S-6BL,AG F-5BR U-12BHU,AB
LYSINE, HYDROXY	U-2
MAGNESIUM	S-67FLSTV,AG F-5AFGXZ U-12FHJX,AC
MALIC ACID	U-2
MALONIC ACID	U-2
MANDELIC ACID, THREE-METHOXY-FOUR-HYDROXY	U-2
MANDELIC ACID, PARA-HYDROXY-	U-2
MANGANESE	S-367FLTV,AG F-5AFY U-125FH,AC
MERCURY	S-AG, F-5F U-25F
METHANE	F-NRW
METHIONINE FREE	U-1BH
METHIONINE COMBINED	U-B
METHIONINE TOTAL	S-AG, F-2 U-12BHU,AB
METHYL ETHYL KETONE	U-2
METHYL MERCAPTAN	F-R
MYINOSITOL	U-H
NIACIN	U-1,AC
NICKEL	F-5AF U-125F,AC
NICOTINAMIDE	U-12
NICOTINAMIDE, N-METHYL	U-12D
NICOTINAMIDE, SIX-PYRIDONE	U-2
NICOTINE	S-V

NICOTINIC ACID	S-3DLTV,AG F-59D U-D,AD
NICOTINURIC ACID	U-2
NITRATES	U-S,AC
NITROGEN	S-TV F-ANWZ U-AC,
NITROGEN, AMIDE	U-2
NITROGEN, NON PROTEIN TOTAL	S-6B,AG U-B
NITROGEN TOTAL	S-67BL,AG F-5B U-12BH,AA,AC
ORNITHINE	U-12U
ORNITHINE FREE	U-B
OXALIC ACID	U-125HEJ,AC
PANTOTHENIC ACID	S-3DV,AG F-59D U-12D,AC
PHENOL	S-ETV F-5E U-12EJH,AA,AC,AD
PHENOL ETHEREAL SULFATES	S-KT
PHENOLS VOLATILE	U-2,AD
PHENYLACETIC ACID, ORTHO-HYDROXY-	U-2
PHENYLACETIC ACID, META-HYDROXY-	U-2
PHENYLACETIC ACID, PARA-HYDROXY-	U-2
PHENYLHYDRACRYLIC ACID, PARA-HYDROXY	U-2
PHENYLALANINE FREE	U-1BH
PHENYLALANINE COMBINED	U-12B
PHENYLALANINE TOTAL	S-6BL,AG U-12BHU,AB
PHENYLLACTIC ACID, PARA-HYDROXY-	U-2
PHENYLPROPIONIC ACID, META-HYDROXY-	U-2
PHENYLPROPIONIC ACID, PARA-HYDROXY	U-2
PHOSPHORUS	S-67FLV,AG F-56AFXZ U-2FHX,AC
PHOSPHORUS, INORGANIC	U-1
PHOSPHORUS, ORGANIC	U-1
PORPHOBILINOGEN	U-H
PORPHYRINS	U-EH,AC
POTASSIUM	S-37FLST,AG F-5AFGXZ U-12KFHJX,AC
PREGNANEDIOL	U-1
PROLINE FREE	U-1BH
PROLINE, COMBINED	U-2B
PROLINE	S-AG, U-12BH
PROLINE, HYDROXY-, CONJUGATED	U-2
PROLINE, HYDROXY-, TOTAL	U-12
PROPIONIC ACID	S-AE,
PROPIONIC ACID, PARA-OXYPHENYL	F-R
PURINE BASES	F-5B U-15BHJ,AA,AC
PURINE, SIX-SUCCINO-	U-1
PUTRESCINE	F-R
PYRIDOXAL	S-6DL U-1D
PYRIDOXAMINE	U-1KD
PYRIDOXIC ACID, FOUR-	U-12D
PYRIDOXINE	S-3DLTV,AG F-9D U-12D,AC
PYRIMIDINE	U-AD,
PYRUVIC ACID	S-AG, U-2HV
QUINALDIC ACID	U-2
QUINOLONE, FOUR-	U-2
QUINOLONE, N-METHYL-FOUR-	U-2
RESORCYLIC ACID, ALPHA	U-2
RIBOFLAVIN	S-3DLV,AG F-59D U-125D,AC
RIBOSE	U-2
RIBULOSE	U-2H
SALICYLIC ACID	U-2
SALICYLURIC ACID	U-2

SARCOSINE .	U-2
SCYLLITOL	U-H
SELENIUM	U-1F
SERINE FREE	U-1BH
SERINE COMBINED	U-2B
SERINE TOTAL	S-AG, U-12BHU
SILICON	U-15F
SILVER	S-AG, F-5FY U-5H,AD
SKATOLE	S-K F-R
SKATOL, ETHEREAL SULFATES OF	S-KT
SODIUM	S-37FLST,AE,AG F-5AFGXZ U-125FHJX,AC
SQUALENE	S-4CMS
STEARIN	U-AD,
STEROIDS, ADRENAL	S-AG,
STEROIDS, ALPHA-KETO-	U-1
STEROIDS, SEVENTEEN-HYDROXY-	U-1
STEROIDS, SEVENTEEN-KETO-	U-1
SUCCINIC ACID	U-2H
SUCROSE	S-KT U-2H
SULFATES, INORGANIC	U-2
SULFUR, INORGANIC	U-1FH,AC
SULFUR ORGANIC	U-H
SULFATES, ETHEREAL	S-K U-12CF,AD
SULFATES INDOXYL	U-AC,
SULFATES TOTAL	S-TV,AG U-2
SULFUR TOTAL	S-3FL,AG F-56AFXZ U-1FHJX,AC
SYRINGIC ACID	U-2
TARTARIC ACID	U-2
TAURINE	U-12BHU
TAURINE, CONJUGATED	U-2
TETRAHYDROCORTISOL	U-1
THEOPHYLLINE	U-1
THIAMINE	S-3DLV,AG F-59D U-125D,AC
THIAMINE, DI-PHOSPHO-	S-AG,
THIOCTIC ACID	U-2
THREONINE FREE	U-1BH
THREONINE COMBINED	U-2B
THREONINE TOTAL	S-6BL,AG F-5BR U-12BHU,AB
TIN	F-5FY U-12FH,AC
TOCOPHEROL	S-M
TRIGLYCERIDES	S-4CMS U-2
TRIGONELLINE	U-1D
TRIMETHYLAMINE OXIDE	U-2
TRYPTAMINE	U-2
TRYPTAMINE, FIVE-HYDROXY-	U-2
TRYPTOPHAN FREE	U-1BH
TRYPTOPHAN COMBINED	U-B
TRYPTOPHAN TOTAL	S-6BL,AG U-12BHU,AB
TRYPTOPHAN, N-ACETYL-	U-2
TRYPTOPHAN, N-METHYL-FIVE-HYDROXY	U-2
TYRAMINE, THREE-HYDROXY-	U-2
TYROSINE FREE	U-1BH
TYROSINE COMBINED	U-2B
TYROSINE TOTAL	S-6BL,AB U-12BHU,AB
URATES	U-H
UREA	S-37KLSTUV,AE,AG U-12BHJ,AA,AC

URIC ACID	S-37BKLSTU,AE,AG U-12BHJ,AA,AC
URIC ACID, ONE-METHYL-	U-2
URIC ACID, SEVEN-METHYL-	U-2
URIC ACID, ONE-THREE-DIMETHYL-	U-1
UROBILIN	U-1KE,AC
UROBILINOGEN	F-2KEGZ U-125EH,AC
UROCANIC ACID	U-2
UROERYTHRIN	U-2
UROPORPHYRINS	U-2H
VALINE FREE	U-1BH
VALINE COMBINED	U-2B
VALINE TOTAL	S-6BL,AG F-5BR U-12BHU,AB
VANILLIC ACID	U-2
XANTHINE	U-12
XANTHINE, HYPO-	U-2
XANTHINE, ONE-METHYL	U-2
XANTHINE, ONE-METHYLHYPO-	U-2
XANTHINE, SEVEN-METHYL-	U-2
XANTHINE, ONE,SEVEN-DIMETHYL-	U-2
XANTHURENIC ACID	U-2
XYLOSE	U-2
XYLULOSE	U-2H
ZINC	F-5AF U-12FH

Section 2. Other Diverse Excreted Substances

ACETOPHENONE O-SULFATE, TWO-AMINO-THREE-OH	U-2
ACIDS VOLATILE TOTAL	S-L F-5
ACTH	U-2
ALBUMIN	S-KT UAC
ALCOHOLS BRANCHED CHAIN	S-4M
ALCOHOLS STRAIGHT CHAIN	S-4M
AMYLASE	U-2H,AC
BACTERIA	U-H
BACTERIAL SUBSTANCES	F-G
BILE PIGMENTS	F-A
CADAVERINASE	U-2
CARBONIC ANHYDRASE	U-2
CATALASE	U-2
CITROVORUM FACTOR	U-12
ENZYMES	F-Z U-H
FERULOYL-GLYCINE-	U-2
FIBRINOLYSIN	U-2
GLUCURONIDASE	U-2
GLYCOPROTEINS	U-H
GONADOTROPHINS	U-2
HEMOGLOBIN	U-H
HISTAMINASE	U-2
HYDROCARBONS AROMATIC	U-AD,
INSULIN	U-2
LIPASE	U-2
LIPOPROTEINS	U-2
MALTASE	U-2
MELANOCYTE STIMULATING HORMONE	U-2
MENOTOXIN	S-AG,
METHEMOGLOBIN	U-H
MUCOPROTEINS	U-H
MYOHEMOGLOBIN	U-H
NORADRENALIN	U-2B
PARAFFINS	S-CS
PARATHYROID	U-2
PHOSPHATASE, ACID	U-2
PLASMALOGENS	U-2
PROTEIN	F-AZ U-1BH,AC
RIBONUCLEASE	U-2
SOAPS	F-CS
UROCHROME	U-2
UROKINASE	U-2
UROPEPSIN	U-H
UROPEPSINOGEN	U-2
WAXES	S-4CS

Section 3. References for Combined Products Tables

Code Symbol From Table	Excretion Product	Page Number In Reference	Reference In Biblio
1	U	363	(Altman-61)
2	U	919	(Long-61)
3,4	S	467	(Altman-61)
5,6	U,F,S.	5	(Wallman-60)
7	S	469	(Altman-61)
8	S	56	(Spector-56)
9,A	F	3,26	(Goldblith-61)
B,C,D,E,F	U,F,S	209-213	(Albritton-53)
G,H	U,F	526-534	(Diem-62)
J,K	U,S	4-5	(Ingram-58C)
L,M,N,P,Q	F,S	8-19	(Mattoni-62)
R	F	21	(Ingram-62)
S	S	53	(Breeze-61)
T	S	1	(Ingram-57)
U	U	579	(Thompson-57)
V	S	210	(Robinson-54A)
X,Y,Z,AA,AB, AC,AD,AE	U,F	258-260,352-368,488	(Sunderman-49)
AF	F	333	(James-61)
AG	S	223	(Kuno-56)

Notes on the Use of the Chemical Substance Tables

Data were sought which would include "normal values"(eg. Spector-Handbook of Biological Data-1956; Sunderman-Normal Values in Clinical Medicine-49). These are supposed to take into account these factors:measurements are made within the North Atlantic(American and European)community, on healthy adults, on normal mixed diets, with environment, rest, workload, intake, and adaptation conditions standardized to common conditions at the time of measurement, and so described.

In general, each reference(eg. Spector-56) provides such information as:mean value and dimensional units, statistical dispersion of values, analytic technique, conditions of experiment, and further reference to original method source paper. For some references, the author has simply assembled values from a number of good sources cited.. The reader may gain added confidence in a mean value of amount of a given substance produced, by combining values from several sources cited in the table.

Caution must be exercised, in extrapolating from the values obtainable from these sources, under temperate conditions, to those circumstances involving high temperature, workload, water or food pattern alterations, or other stresses, which can greatly change the amounts of released substances. Additional help on this may be obtained from references cited in this report on changes in body products under heat stress conditions.

For supplementary data on other urine, feces, skin products not in table, see discussion pages on these substances which follow.

Utilization of the data in various studies suggested in this report would be aided by arranging the substances in the table into categories based on major chemical structural groups and arrangements.. This can help in study of separation processes(eg based on solubility, mobility, diffusion, reaction specificity, etc), on analysis of spectral properties, on matchup with specific biosensor chemosensitivities, etc. Another useful grouping would rank the substances in order of absolute amount from all channels, released into environment, on a daily basis(eg. total chlorides from feces, urine, skin/day). The top group might be selected for preliminary analyses of system sensitivities, etc. The same grouping can be used to aid in selection of substances which would show high contrast ratios with other materials in environment, or are uniquely identifiable as produced by humans or higher animal organisms. These could include, for example, low molecular weight hormones liberated in trace quantities such as steroids, adrenalin and catecholamines;it should also consider substances poorly defined chemically(and not on the table), of high molecular weight, including proteins & polypeptides, lipopolysaccarides, which even in minute traces can be identified as unique to the individual and species by serological methods.

b. Additional Data on Specific Body Products.

1. Skin Products

(a). Sweat .

Supplementary data on sweat composition includes the following: Iron(Consolazio-63B), (Mitchell-49), vs diet(Johnston-50); Calcium(Consolazio-52)(Johnston-50)(Mitchell-62A);Sodium(Bulmer-54), (Consolazio-63-B);Potassium (Bulmer-54)(Consolazio-63B);Chloride (Ladell-48). For Nitrogen compounds(Mitchell-62A)(Consolazio-63A, 63C), vs. diet protein and salt(Cuthbertson-34). On other composition factors: for salt composition(Werner-52)(Gibbs-62A); composition and colligative properties(Foster-61); solute excretion rate, physiological factors(Barrueto-59), (Bass-59).

Source data on sweat composition and volume also exists in papers on thermoregulation. See: evaporation studies(McCutcheon-55), (Taylor-53A, 53B);rate and discharge patterm(Albert-51)(Peiss-51);for responses to high temperatures, see(Lloyd-61), salt and water endocrine control(Collins-63); high temperature responses as function of humidity(Lyburn-56), and of acclimation(Dill-38)(Von Heyningen-49). For studies of desert responses, see (Adolph-47), for other temperature effects(Lloyd-61).

For other related references on sweating:for measurement, see (Robinson-54B), drugs altering sweat mechanisms(Randall-55), skin evaporation with inactivated sweat glands(Pinson-42), sweat glands as extra-renal regulators of chemical substances(Schwartz-60), comparative physiology(Schuman-62), sweating in illness(Lobitz-61), lack of ethnic differences claimed in basic sweating pattern(Hansen-61), and recent general reference(Schuman-62).

(b). Sebum.

Supplementary data on this special glandular secretion includes the following:Sterols: cholesterol(Boughton-57), others(Brooks-56)(Spector-56), (Ramanathan-58)(Boughton-59)(Horacek-59). For fatty acids:straight chain saturated and unsaturated, with under 20 carbon atoms, see(Boughton-59),(Javes-56) (Spector-56); including caproic and caprylic(Eller-41);capric(Decanoic)(Jones-56). No branched chain or hydroxy fatty acids are seen in Spector's listing. Some fatty acids on skin are believed to be derived from sebaceous gland lipids, split on skin by lipase in normal bacterial flora(Strauss-59). Other Lipids: triglycerides(Horacek-59), di and tri glycerides, waxes(Haahti-61A), phospholipids(Wheatley-53), choline lipids and plasmalogens(Horacek-59), other unsaponifiable fractions(Boughton-59A, 59B). Alcohols: straight and branched chain(Spector-56), others (Boughton-59). Squalene :(Mackenna-50)(Wheatley-53)(Spector-56)(Ramanathan-58), (Haahti-61A). Other hydrocarbons:(Spector-56).

For other sources of information on composition, for that from individual glands, see (Suskind-51), for composition independent of dietary factors (Ramanathan-58) but altered in disease(Schmidt-Nielson-51)(Wheatley-56), and for survey(Mackenna-52).

For homeostatic control of sebum production, and its alteration by endocrines, see (Hershey-59)(Horacek-59);for relation to sex hormone activity (Strauss-56), alteration in output in females by drug Enovid(Strauss-63), and in males vs. male and female sex hormone administration and castration. These latter

responses give rise to the interesting speculation that sebum and its gland are remnants of a scent communications organ(Schaffer-37)(Wheatley-56), of the type described for various animals and discussed in this report, and that the gland product as released (or unmasked by bacterial action on skin) matches active and existing chemoreception processesin man, with perhaps a subconscious perception of the event, and consequent action in human relationships. (Note that the perfumer's blends include animal scent substances; Norbert Wiener calls perfumes 'exterior hormones'). Human sebum products are believed by various tracking dog handlers to be the principal class of sub-stances produced by man and smelled by the dog in tracking. (See Biosensing, Dogs). One class of important experimentswith sebum which must be carried out is to prepare quantities of whole sebum, or its fractions(chromatographed, etc) for use in controlled dog tracking experiments.

For other information on the sebaceous gland; for its biology, see (Rothman-54)(Kuno-56)(Kilgman-58)(Shelmire-59). For analytic methods, for early quantitative determination(Emanuel-36, 38), for collection techniques, see(Van Heyningen-52)(Strauss-51);for modern gas chromatographic micro-analysis of many sebum products, see(Haahti-62), who also uses Infrared detection with one chromatograph(Haahti-61A).

(c). Skin Product Alteration by Bacterial Action..

The normal skin bacterial flora, described by(Levans-50), is one agent responsible for the transformation of known groups of substances released from the several glands, into a time-dependent uncertain mix of chemical substances, requiring further identification by chromatography, etc. Bacterial lipases are claimed to split fats into fatty acids, and contribute to odor(Strauss-59). See also (Strauss-56). Other non-bacterial enzyme degradation, autolysis, probably contributes other fragments to this brei.

(d). Skin Products Attracting and Repelling Animals..

For many mosquito studies on skin products, see(Brown-51, 56), (Rahm-57A, 57B), for mechanisms of attraction: see(Rahm-58A, 58B), for individual human differences sensed(Brouwer-59, 60), for identification of the specific palpa and tarsal chemoreceptors involved(Rahm-58A), for skin amino acids as major attractants(Brown-61A), including lysine(Brown-61B). For other mechanisms of attraction of mosquitoes to humans, see(Mer-47), (A Parker-48), (Willis-47, 48), (Thompson-55).

For a study of human skin products, particularly serine, repelling fish (salmon), see (Idler-55).

(e). Human Odor from Skin.

For body odor in man, its reception, significance, control, see (Neuhaus-61), for human individuality in odor(Laird-35)(Lohner-24). For individual and ethnic difference studies, see(Eller-41)(Adachi-03)(Laloy-04A, 04B).

(f). Other Sources of Data on Skin Properties and Products).

For reviews on skin, see(Markowitz-42)(Rothman-54)(Kuno-56)(Shelley-58). For eccrine gland studies, see(Lobitz-61)and apocrine glands(Shelley-60);for factors affecting secretion process(Kerslake-54)(Kawahata-53), for neural regulation and emotional stimuli(Kennard-63);and for other skin physiological data (Lemaire-56). For apocrine secretion correlates with sex hormones, see(Straus-56), and for induction of asthma by skin products, see(Jamieson-47).

2. Urine Products

For supplementary data on urine components:for basic amines, see(Scriber-59);amino acids(Stein-53)(Evered-54, 56)(Soupart-59)and their seasonal changes(Hale-59), polypeptides(eg. aspartyl, glutamyl)(Buchanan-63). For protein trace concentrations quantitatively determined in normals , see (Tidstrom-63). For 17-OH-corticosteroids(including pregnandiol), see (Garlock-63).

For other papers of utility in this study:for Ca and Mg vs. galactose input, see(Heggeness-60);for aldosterone vs. heat acclimation(Fletcher-61), electrolytes vs. cold diuresis(Bass-54);for other dietary influences(Sargent-56). For a good sequence of papers identifying urine components in closed cabin wastes, see(Ingram-57, 58A, 58B, 58C, 61, 62).

3. Fecal Products.

For additional data on composition; for sterols,see(Aylward-62); for other common lipids(Watson-37)(Gordon-57),also measured in S. African whites and Bantus(Antonis-62). For bile acids vs. diet fat(Gordon-57)(Haust-58). For Ca & P in Africans(Holemans-62). For several references identifying fecal solids and liquids in closed recycling systems, see(Ingram-58A, 58B, 58C, 62).

For g.i. gases, composition and quantity, see(Kirk-49)(USAF Handbook of Bioastronautics). For colonic amounts, see(Fries-06), alteration with diet in rats(Hedin-62)(Whitehair-62); forformation vs. diet in humans, Japanese(Kodama-49); for volume in the whole g.i. tract(Blair-43, 47B)and in colon(Fries-06), for alterations with altitude(Steggerda-47, 55).

4. Respiratory Products.

For normal persons breathing atmospheric air of standard composition, the only products archived in the literature are the usual O_2, N_2, H_2O, CO_2, for expired air, even in the literature of closed system studies;and no information on other substances enters the combined chemical substances tables. Information available turns out not to be directly applicable, on expired products under other circumstances;in disease states(eg. acetone in diabetics)(Steward-61);g. i. and respiratory products expired deriving from unusual foods(eg. garlic)(Haggard), and substances expired after the detoxification and excretion of drugs and poisons(as described in the several handbooks of toxicology.

c. Other Supporting Information on Body Products

1. Ethnic and Regional Differences in Human Products

Some data providing ethnic comparisons and geographic regional measurements (other than North Atlantic values), on urine, feces, skin products and certain physical properties, are set down on the following pages. Such data were found to be sparsely scattered through the literature, and should be considered illustrative but not complete. They were obtained in an intensive search for "normal values" tables and lists from other regions, using a variety of Boston and East Coast reference collections. To go further, the reader might seek regionally published medical teaching texts on biochemistry and physiology, clinical pathology, civil hospital center and military medical service manuals on clinical lab technique, normal values, experience data.

Except for data obtained by authors carrying out comparative ethnic studies, it is hard to determine whether values are related basically to ethnic considerations, and if experiments balanced out factors of climate, workload, health vs disease, body size and weight, diet, various adaptations, and considered other experimental standard conditions. Only if the true controlled-experiment ethnic base data can be extracted from these papers and others by the same productive authors, a table of values could be built for each group for comparison with "North Atlantic normals" in attempt to unearth significant differences in individual components concentration, or mixture concentration profiles.

Urine Components: Ethnic comparisons were made, for amino acids: in Europeans, Malaysians, Chinese (who showed high taurine (McEvoye-Bowe-61), in Chinese vs. caucasoids with diet ruled out (Chinese show higher alanine, lysine, tyrosine, histidine, B-amino isobutyric acid) (Sutton-55). Comparisons were made, for 17-Ketosteroids and creatinine in Indians, Chinese, Malaysians, Negrito, Senoi (Lugg-57), for 17--Ketosteroids in North and South Indians, Europeans and African negroes (Barnicott-62). To compare nitrogen products and vitamins for several groups, Interdepartmental Committee on National Nutrition for National Defense Surveys of : Thailand, Ethiopia, Lebanon, etc. For various minerals, (traces of (Mn, Cu, Pb, Al, etc) in French, Americans, various Mexican groups including Indians see (Kehoe-40) who relates these values to the mineral distribution in the soil where these individuals spent their early life. This can be an important "tracing tag".

For specific regional measurements: for India, for nitrogen fractions, for urea, creatinine, ammonia, as function of diet, see (Ramamurti-55) for amino acid, urea and ammonia values (Phansaekar-54) for other nitrogen (Gokhale-63). For 17-Ketosteroids, in normal and under-nourished (Ramachandran-56); North vs. South Indians (Barnicott- 52); for relation to estrogens, pregnandiol (Patwardhan-57) and (Friedman-51), (Bharadwaj-57) and other studies related to serum Na and K (DasGupta-56). For adrenalin and other catecholamines, see (Subrahmanyan-60)(Sheth-62). For creatinine see (Lugg-57), sulfur (Pathak-61); chlorides (Ramanathan-60)..

For Japanese, for amino acids see (Muratar-59) and related genetic studies (Iwata-59); 17-Ketosteroids (Jap. Nat. Inst. Nut.-60); Ca (Ishizawa-62); Na and K (Fujioka-60); various bases (Yamamoto-59); and general urinalysis (Saito-60) (Fujii-56).

For Chinese, for amino acids (lycine, alanine, taurine, glutamine, cystine, B-amino isobutyric acid) see (McEvoye-Bowe-62) and (Sutton-55) whose measurements are cited under ethnic comparisons. For alpha-keto acids (puruvic, alpha-keto glutaric acid (Liu-62); creatine (Bowress-58); 17-Ketosteroids (Bowress-58) (Lugg-57), thiamine (Liu-62); Coproporphyrin (Dept. of Indust. Health, Szechuan, China-60).

For Malaysians, for amino acids (McEvoye-Bove-61), 17-Ketosteroids (Lugg-54, 57).

For Africans 17-Ketosteroids (Barnicott-52) and in West Africans, 5 -hydroxy-indole-acetic acid (Foy-62).

Fecal Components: For ethnic comparisons, for minerals in French, Americans, various Mexican groups, see (Kehoe-40) discussed under Urine.

For specific regional measurements: for Africans; K and P (Holemans-62); South Africans, bile acids (Lewis-57), lipids vs. diet in whites vs. Bantus (Antonis-62); Japanese: intestinal gases, related to diet (Kodama-49); for Ethiopia, Lebanon, Thailand proteins, other nitrogen, vitamins (see (Interdept'l ctee. Nut. Nat. Def.) papers cited earlier.

Skin Products: For regional measurements: India; sebum composition (Ramanathan-58), iron (Hussain-59, 60; NaCl with heat and exercise (Ramanathan-56). For Africans; nitrogens, as ammonia, urea (Darke-60).

For ethnic comparisons, of sweat gland distribution differences in Eskimos; Negroes, Caucasians see (Kawahata-61) and see material under biosensing, human smell for papers discussing ethnic odor differences.

Physical Properties

Skin spectral reflectance ethnic comparisons were made, for white vs. negro in the visible region (Buttner)(Kuppenheim-52), (Pfleiderer-62), in the infra red (Wright-34)(J Hardy-56)(Buttner)(Kuppenheim-52) (Pfleiderer-62) and in the ultraviolet (Jacquez-55A) (Pfleiderer-62). For similar measurements, in Japanese: for visible and IR, see (Jacquez-55D), for UV see (Jacquez-55A); For Mexicans, see (Lasker-54). For other spectrophotometry for skin color see (Weiner-52) skin color used to study inheritance (Harrison-56); for spectral reflectance differences with age, sex, race, see (Edward-39).

Other Ethnic Comparisons in Biological Data:

For heat acclimation comparisons vs. anthropological difference (Newman-55), Europeans vs. Asians (Adam-53) white vs. American negro (Baker-58A) and white settlers in tropics (Price-39), for others, see (Baker58B) (Strydon-63). For various diseases, ethnic, sex, race, vs. host factors (Damon-62), disease ecology (May-58, 61A), psychiatric ecology (Meerloo-59). For Far East malnutrition ecology (May-61B).

2. Regional Diet and Nutrition Data Sources.

Data set down in the combined substance table and supplementary lists derives chiefly from people under normalized conditions, including mixed diets of North Atlantic countries(European and American). In looking for excretory products data and diet data from other world regions, extensive review of the past and present world literature in many document collections, and in at least fifty periodical titles in nutrition, metabolism, dietetics, etc. has not revealed much information presenting human excretory products in orderly array, directly related to diet or diet modifications, except in malnutrition states.

To explore further available information on dietary influences on body product, the reference sources set down in this section may prove of value, beyond their first review for this report. To go further with the problem, the reader must seek data going beyond generalized nitrogen balance studies which represent most of what is set down about body products in these papers. Ethnic and Regional Difference data referred to in the adjoining section probably are contaminated with a major factor relating to diet composition, which a discerning reader may be able to separate out for significant diet and body product correlations. Additional references from the same productive authors listed should be consulted, and the pursuit of indigenous texts, manuals and other publications, in the manner described in the Ethnic section, is recommended.

For Far East data on diet and nutrition: for Indonesia, see (Postmus-55); Thailand (US-ICNND-61); Malaya (Leong-52); India (Wittfogel-57); (Hussain-51); China(Wittfogel-57)(Worth-63); Formosa(Jolliffe-56) & Chinese Nationalist Army (Pollock-56); Pollack's is an especially good series of several papers in a symposium on Far East nutrition, with metabolic, anthropological, and clinical approaches, including limited balance and excretion studies.

For other regional data, for studies of the Interdepartmental Committee on Nutrition for National Defense, consult Dr. Arnold Schaeffer at National Institute for Arthritis & Metabolic Diseases. For tropical nutrition, see(Nicholls), (NY Acad of Med. -60). For regional protein malnutrition studies, see long series of papers by Dr. Nevin Scrimshaw, of MIT Dept. of Nutrition. For other malnutrition data, on starvation, see(Keys-50)(Gilman-50); and for Far East malnutrition(May-61).

For other general references on nutrition and its correlates: see the food encyclopedia(Ward-41), biblio(Baker-58), general text(Joliffe-62), and comparison of world's food(Bennett-54); for food habit research, see(Bottlieb-61), & habit origins(Renner-44), unusual foods(Black-53), meat taboos(Simmons-61), other strange food customs(Harris-62), balance in strict vegetarian diet(Guggenheim-62); for environment effects on food habits and intake, see(Peryam-60), for nutrition and climatic stress(Spector-54A)(Buskirk-57) and high temperature nutrition(Salganik-59).

For food chemistry, see (Jacobs-51); chemical composition tables (Chatfield), and comparative data(Harris-48); for trace elements in foods(Underwood-56). For nutritional biochemistry and status studies, see(Lowry-52), (Bourne-53), (McCance). For protein needs and excretory products, see(UN-WHO), (Spector-54-B0(Allison-60). For survival ration needs, see(Roth-43)(Davies-55).

3. Closed Cabin Ecology Studies..

Data have been sought for additional definition of human body products, from those studies of closed environment systems where such information is of great significance in the design of life support controls and recycling and recovery systems for certain substances. For general studies:for extraterrestrial bases, see(Holbrook-58)(Bates-61), on aerospace cabins(Konecci-59), (Clamann-58), on Soviet space systems(Gazenko).

For environment (gas and vapor)composition, including human products: for space cabin contaminants measured by gas chromatography revealing much organic detail, see(McKee-63). For submarine environment,contaminant measurement, data and techniques, see the many papers of (Nestler-58, 59), (Piatt-60A, 60-B)(Ramskill-60); others on organic contaminant identification (Johnson-56, 62), (Thomas-60)(Umstead-60), and (Miller-60). Of special value is the chemical analysis and description of non-human sources of contamination in submarine environments(foods, tobacco smoke, lubricants, plastics, etc) by(Arnest-61).

For design information relating to closed environment human products and atmosphere composition, see(Chasen)(Palevsky-57)(Bursak-60)(McCandles-60), (London-62)(Dryden-56)(US-ASTIA-Bib-62). For waste disposal,for recycling of identifiable components, for feces(Goldblith), comprehensive studies of (Ingram-56, 58A, 58B, 62), also(Golueke-59)(DesJardins-60). For closed system water purification and other recovery, see(Fair-54)(Konikoff-60, 61)(Bennett-58), (Ingram-58C)(Zeff-59)(Olson-61)(Rich-61)(Mancinelli-63), extensive review (Pipes-NRC);, and other papers on urine recycling(McNeil-54)(Moir-59)(Sendroy-59)(Hawkins-58)(Ingram-61).

For contributions which these measurements procedures used by some here can make to the human products sensing problem, see(Chemical Products Sensing, Physical Methods), in this report.

4. Human Chemical Composition.

Information on this attribute of human tissue can aid in study of remote sensing systems involving physical links related to atomic and molecular composition, described elsewhere herein(eg. x-ray fluorescence, radioactivation analysis, reflectance spectroscopy in all regions).

For general chemical composition, see Handbook of Biological Data (Spector-56), & (Piron-Reatequi-61).

It would be desirable to look beyond the studies of (Kehoe-40) who investigated variations in human excretory products (trace minerals)related to soil composition of environment where subjects had grown up;into review of body composition for the same minerals correlated with environment of origin.

II. Physical Attributes.

a. Electromagnetic Radiation Contrasts

1. Infrared

For skin spectral reflectance measured to 1 micron (U), see (Jacquez-54, 55B) (Kuppenheim-52) who shows White max. 0.7-0.8U, Negro max. 0.9U. Further out to 2.5U, (Jacquez-55D) claims 55% total reflectance to 1U, 5% beyond to 2.5U, with all Negro-Japanese-White differences under 1.2U, and (Hardy-56) describes angular variations, in isolated skin. For data to 10. U and 3.5U Negro peak versus White skin, see (Buttner) and for earlier data to 14. U for Negroes and Whites see (Hardy-34A). For other diffuse data see (Clark-53).

For transmission and absorption data (from which reflectance may be inferred), to 2U, see (Hardy-34); to 2.5U (Pfleiderer-62); for skin reaction from IR (Hardy-54) including heating (Hendler-57).

For skin spectral emission, 1-14U, showing emissivity over 0.99 for White and Negro skin above visible, see (Hardy-34A) (Wright and Telkes-34), and 1-15U in isolated skin, White and Negro (Hardy-56). For "IR" radiometry of whole body for clothing design, see (Veghte-61) discussed as "thermography" (Barnes-63).

For nervous system emission speculation, see (U.S.A.F. Procurement Office, Aerospace Med. Lab., Dayton) invitation for study on possible emission of "non-thermal" IR from CNS.

2. Visible

For skin spectral reflectance, see (Buettner-37) (Goldzieher-51) (Derkson-52), (Kuppenheim-52), (J. Weiner-52B) (Jacquez-54, 55A, B), (Hardy-56) (Harrison-56), good work of (Buckley-61), A.F. Special Weapons studies (Derkson-54); for diffuse reflectance (Krolak-55) and changes after sunlight exposure (Edwards-39).

For skin spectral transmission data, see (Hansen-48), annual report lists of Naval Materials Lab, Brooklyn Navy Yard on Simulated Weapon Thermal Pulse Studies.

For clothing and personal equipment data, see (Krolak), also QM Laboratories clothing and textiles reports in their annual lists of publications.

3. Ultraviolet

For skin reflectance from 200 MU to edge of visible, 8% total reflectance stated by (Goldzieher-51), describing in detail bands seen due to amino acids (e.g. tyrosine) at 290 MU, also proteins, nucleic acids, hemoglobin, melanin, and carotene, UV excitation adds 20% to reflectance in non UV regions (Jacquez-54) who from 200 MU up finds no Japanese, White or Negro reflectance differences, but hemoglobin bands common to all at 420 and 600 MU, (Jacquez-55A). For other reflectance spectrophotometry of different skin layers after UV erythema, see (Jansen-53).

For skin transmission data 220-360 MU, see (Runge-62) and UV transmission through various skin layers (Bachem-29) (Hansen-48A, B), and UV skin spectrometry (E. Edwards-51).

For interesting property, after 250 MU excitation of skin (isolated), free radical production, measured by Electron Spin Resonance (ESR) (Norins-62)

techniques. This contrast factor could give rise to possible new class of non-contact detection methods (see Physical Methods for Chemical Analysis, in this report).

4. Microwave and RF

For skin reflectance (data quite hard to isolate from the wealth of diathermy absorption and action data), 70% reflectance, at 1.27, 3 and 10 cm. (like water) claimed (England-49, 50). From 3-300 cm. reflectance 60%-100% stated (Maskalenno-58). For other 3-300 cm. measurements (Nieset-61). 50%, from 3-75 cm. inferred from absorption cross section data (Anne-61).

For body absorption data (for inference of other reflection properties) see (Rajewsky-38), (Saito-60), (Anne-62). For mechanisms (Schwan-56A, B) including coupling and interactions in diathermy Schwan has published much on dielectric constant and conductivity by differences in various isolated tissues (Schwan-54), and 3-75 cm. measurements in human "phantom" replicas (Anne-61).

For clothed person reflectance in cm. and mm. regions (radar cross-sections) and properties of anti radar detection clothing, see (U.S. Army QMR and E Procurement Office) for recent invitations for proposals to study these, and for background reports which preceded these IFP's.

For body emission, the normal heat emission from man with maximum radiation in the near infrared, has a continuous "tail" into the microwave region, discernible from background with a sensitive microwave radiometer (see Physical Sensing).

For speculative information of RF excitation of man producing "heterodyned" radio signal emitted from brain see (Cazzamalli-25). A book reprinting several years of his work, published in Italian in 1960 is reported to exist by ERDL personnel (M. Gale, Mine Detection Branch).

Note that microwave and tissue interactions are involved when ESR (electron spin resonance) techniques are used to view free radicals produced in skin by UV excitation (see UV above).

Also speculative is the suggestion that CNS produces very low frequency (under 1KC) low intensity radiated signals. No observations were seen published on checking this hypothesis with currently available nanovolt sensitivity very low frequency receiving equipment and amplifiers, such as are used for atmospheric whistlers, geophysical seismic electric and magnetic field data, solid state phenomena, etc.

5. X-ray Contrast

No specific data on reflection or back-scattering can be reported here, but a potential contrast factor lies in the human body elemental composition, abundances of certain elements (e.g. calcium and phosphorus) in certain special configurations (skeleton) perhaps atomically distinguishable by x-rays from other organic and mineral background.

Encouragement derives from ERDL study reports (Porges-58) (Gravitt-62) on x-rays for mine detection (e.g. for mercury, etc. in the explosive accessories). Signal return possibilities from tissue include x-ray fluorescence techniques (x-ray return signals in back-scatter at longer wavelengths than exciting beam of 220 KV energy, and characteristic of certain

elements, requiring very stable high intensity X-ray source, energy-sensitive detector, etc);and elastic(Rayleigh)back scattering, again using sources over 100 Kv. It may be worthwhile in a short study to examine intrinsic factors of X-ray contrast in humans; parameters which govern their excitation and their detectability in background; and the available possibilities for obtaining the required new sources(of high intensity, narrow beam, pulsed, narrow band, highly stable-perhaps all in a fashion describing a hypothetical coherent x-ray laser source);also suitable detectors.

b Sound and Vibration Contrasts

For human body surface sound reflection data, given as 1-2% for 1-20 Kc/s, see (Ackerman-62). Further inferences on reflection may be made from papers on: mechanical impedance of body surface(Franke-48, 49, 51A, 51B), (Von Gierke-50, 52, 59), (Ostreicher-50), (Ludwig-50), and other reports listed in those report summaries from(USAF Bioacoustics Lab-WADD-60), and CHABA (Committee on Hearing and Bioacoustics)report list(Whitcomb-63). For other data on ultrasonic interactions, see(Lehman-53), (Kelly-57), (Heuter-58).

On sound emission: human movement creates sound;not only walking, etc., but activity "at rest"(to change weight and contact pressure distribution, circulation return -a series of obligatory movements, without which discomfort and actual lesion develop, as in bedridden paralytic decubitis ulcers). While measurements of such noises would seem to be easy, no good systematic data on this could be found, even in search on exaggerated movement, among disturbed persons, as might be recorded in the psychiatry journals. Possible sources include Human Engineering data(e. g. Franklin Institute and Case Institute of Technology various studies on body-seat contact pressures and measurements), information from rehabilitation and physical therapy sources.

Normal respiration contributes a very minor sound background, except after very intense exercise, There was sought without success data on normal respiratory external airborne sound measurements;none appear in major respiratory normal or pathological physiology sources. Perhaps sound spectrogram data are to be found in back files of acoustical journals (eg. JASA) and speech communication periodicals(eg Bell Lab Tech Jnl.).

Ejection of blood from the heart produces a body recoil pattern externally measured clinically as the BCG(ballistocardiograph). See (von Wittern-53), many papers of Isaac Starr. This signal level is much to low to excite micro seisms which would be detectable even in the ground immediately around the man.

No characteristic data have been found on noises of daily tasks, food preparation, weapons handling, except the few on shipboard crewspace noise listed under Environmental Modifications. For other data on sound and vibration contrasts, see section on Interaction of Sound with Humans, under "Behavioral Responses".

c. Electrical Properties.

Internal sources of systematic biopotential pattern observed include the heart, various muscles, brain, etc. with signals manifest in skin surface measurement of repetitive signals in some cases, at millivolt levels(electrocardiogram), microvolt levels(muscle electromyogram, eye electroretinogram, eeg). No non-contact or remote observation techniques for these phenomena have been found explicitly reported in the literature to date.

No other human electric field emssion or pattern is reported, although

it is claimed(Burr-49) that electric fields are produced around nerve tissue (isolated nerve, 150 microvolts measured at 1 cm), and that persistent electrical field configurations found around organisms and within them, are associated with growth patterns, etc(Burr-34).

No published data were found on human disturbance of natural earth electrical fields(described under Environmental Modifications..), or remotely measurable interactions with strong fields applied to surroundings. Such information might reasonably be obtained experimentally by placing humans in the environments of sensitive terrestrial electric field observatory instruments, as maintained as several Federal Geophysical research stations.

For other data on human and animal electrical interactions, see Electrosensing(under Biosensing) and Electric Signals Inducing Sensation(under Induction of Behavioral Responses).

d. Magnetic Properties.

Search of the literature reveals no data reported on human production of magnetic fields, although (Morrow-60) describes measurements of magnetic fields around neurons, in isolated nerve. Contact should be made with the Proceedings of the Annual Biomagnetics Conferences(Barnothy-62), the continuing reviews on biomagnetism(Alexander-61), (Jacobius at Library of Congress).

No data are available on human disturbances of the natural geomagnetic field or its rapid minor fluctuations, or detectable interactions with strong applied magnetic fields, as measured remotely. Simple field experiments, on such possibilities and on the detection of the human inhomogeneity in the surround, might be carried out, for example, in the vicinity of the subgamma-sensitivity magnetometer array at Boston College, where observatory for geomagnetic fluctuations is maintained for Air Force; one should look into experiments possible with aid of Naval personnel involved in sea surveillance magnetometer instrument development(Naval Research Lab; Naval Air Devel. Center, Johnsville)

For other data on living organism behavioral responses to magnetic fields (without identification of discrete sensors), see Magnetic Field Sensing, under Biosensing; for magnetic fields inducing human sensation, see Induction of Behavioral Responses in this report.

e. Radioactivity.

Natural radioactive isotopes in human tissue emit signal(K^{40}, also C^{14}, Cs^{137}, Ca^{45}), described by many(Hirsch-55) and measured on large groups for control data on fallout(Onstead-60). Though the low signal is normally measured in the laboratory in low level systems compensated for background, and with long time integration, improvement in detection theory and instruments may bring observation of human self-emission into the realm of possibility for close ranges, for elements of higher abundance in tissue than in environment, and those with certain emission peculiarities.

Radioactivation of specific chemical elements in body to yield radiation and particle emissions with characteristic energy and decay patterns, has its counterpart in chemical analysis techniques(described under Physical Methods of Chemical Analysis). This has been a sensitive technique for body products brought to the measuring apparatus(Tobias-49).

Phosphorus, Potassium, Sodium are thus observed(Reiffel-57);Strontium, Barium, and many trace elements(Harrison-55). Also see radioactivation analysis biblio(Gibbons-57).;nuclear radiation interactions with optical, thermal, electrical and other physical properties of solids(Gex-61), and neutron radiography techniques(Schultz-61).

One may speculatively consider exploitation of these concepts, by remote illumination of subject, with bright collimated beam of suitable high energy radiation or particles, penetrating air for useful ranges, for which relatively large absorption cross sections exist in elements characteristically abundant in man(relative to environment), with back-scattering and re-emission of usable levels of some different characteristic emission, efficiently sensed by detector with appropriate background discrimination properties and response time. Encouragement in part(for the detection aspect can dervie from analyses made over several years, of practical radioactive all-weather glide-path landing aids for aircraft(Haefner-62). These provide, for ground-to-plane path lengths to several hundred feet, sharply defined spatial patterns and beams, allowing adequat e glide angle resolution, with measurement response times short enough for useful attitude and glide path control, without aircrew hazard from received radiation. In their case, they used Co^{60} pellet sources, in small lead boxes with collimation apertures, planted on ground. In the case here, human stimulated emission return will be extremely low level, unless the analysis considers delivery of very large radiation of particle fluxes to the target(and these may in themselves be incapacitating).

f. Body Profile and Geometry

A variety of active and passive observational techniques require knowledge of body configuration and its projected area presented at various positions of rest and work. For these Human Engineering data, consult(Hertzberg-56), (Hansen-58). For effective human radiating area (applied to IR studies) see (Bohnenkamp-36), (Gruber-51). Similar data are obtainable on effective physical cross-sections, from sources cited herein on "Electromagnetic Radiation Contrasts".

D. ENVIRONMENTAL MODIFICATION OF SIGNALS FROM MAN

Analysis of remote detection of some human signal or property must consider distortion of this signal in environment due to background "noise", and transmission loss factors. To get at this problem source data are available and cited below, on bioenvironment (animal and plant) systematic description; chemical environment background (from animals and plants) and chemical transmission factors; physical environment: background and transmission, for electromagnetic, acoustic and seismic, and electric and magnetic field properties of earth. Radioactivity background is not discussed because of the common availability of source information.

I. Systematic Descriptions of Bioenvironment.

Systematic data are available for various regions of the world on gross and fine structure of the flora, fauna, mineral, topographic, other geological, climatological nature of the environment. Where additional structural detail was needed, specific classification systems were set up for vegetation and for land forms (Dansereau-58) (Wood-61) (Carr-62D). These were reviewed and tested at the Waterways Experiment Station (U.S. Army Waterw. Exp. Stat. -61), (Maxwell-62). Such structural detail may include dimensions (height, crown, stem, diameter, shape) distribution (spacing, canopy cover, arrangement) leaf nature and seasonal change. These give the analyst here some idea of background environment structure to examine more closely for detection contrast. Bio-ecology sources can also provide data on indigenous animal types, density, movements; biological handbooks (e.g. Spector-56) yield info on excretory products composition.

Bioenvironment regional studies include: Ceylon vegetation (by air) (Chapman-47), Indochina plants (Amer. Inst. Crop Ecol. -57A), S. E. Asian, Chinese and Formosan plants and agricultural practice (Amer. Inst. Crop Ecol. -57B), comparison of S. E. Asia with Hawaii (Chambers-61) and other S. E. Asia data (Meigs-QM-53).

II. Chemical Substances in Environment and Chemical Substance Transmission.

Substances in environment which may obscure the chemical signal from the concealed man include animal excreta and scent substances, plant materials, chemical products from equipment (e.g. weapons, foods, clothing).

a. Measurements in Air

Air observation for chemical particulates and vapors are made routinely; for pollutants (McCable-52) (Mallette-55) (Taber-58); for organics in city air (Jacobs-57); and biologicals (Amdur-61); and in extensive measurements in various locales by Army personnel from Dugway Proving Ground, Edgewood and Detrick, Maryland (e.g. sampling of airborne particles) (U.S. Army Biological Labs-53, 56); by A. E. C. for effluent analysis (U.S. A. E. C. Div. Reactor Devel Air Cleaning Conf. -60); P. H. S. Taft Sanitary Engineering Center.

From such sources at least two kinds of data can be obtained: archives of materials in air, and capabilities of air background measurement techniques. For information on instruments and standards and Air Pollution Handbook, see (Amer. Conf. Indust. Hygiene-62).

b. Substances from Animals

1. Excretory products

Metabolic excretory product composition and quantity for specific animals in large part is set down in Handbook of Biological Data (Spector-56) (e.g. pp. 247). One must turn to the regional ecology and animal geography studies to determine in a given locale what animals, their density and movements exist, in order to assess this total chemical pool of excreted products. Such data will allow assessing chemical interference levels of substances similar to human wastes (deposited on ground or in air), their "contrast ratios" (amount of a substance from in air in environment/total amount from all other sources), and determination of chemical products really unique to man.

2. Scent products

Animal "scent" substances are produced by many species (see description under Biosensing); in most cases, released from a specific gland into environment, onto ground, trees or into air. These substances are sensed by the chemoreceptors, sometimes in phenomenally low concentrations, and influence the behavior of a member of the same or other species, for food finding, warning, navigation, territorial marking, mating. This is a widespread communications system in nature, and has been poorly studied to date, perhaps awaiting the analytical biophysicist's approach. Such "scent" substances (many are well described chemically) may present background interference in environment, or can yield clues for selected biosensors to sensitivities to selected substances found in human chemical output.

c. Plant Substances

Plant chemical substance backgrounds in environments of interest are not so easy to find and describe. It is possible that those investigating utility of higher plants in closed ecological systems (U.S.A.F., N.A.S.A., Boeing, Martin-Marietta, Electric Boat, etc.) would have collected such products, though no descriptions of plant excretions into air have been found.

Subjective observations of flower fragrances, wood and leaf mold scents, not to speak of crushed grass and broken stems, may have their counterparts in perfumer's chemical description of floral fragrances, and the soil microbiologist and plant physiologist descriptions of processes and products of soil decomposition.

d. Chemical Substance Transmission in Air

Transmission properties of air environment. Once particles, droplets

aerosol, or vapors of human products enter air, their movements in air are subject to considerable uncertainty, with mechanisms only partly understood. For analyses, see (Lettau) and other Ft. Huachuca work; (U.S. Army Chem. Corp Symposium-54) and other Edgewood, Detrick, and Dugway indexes of reports relating to dissemination and detection of chemical and biological agents, aspects of movement of substances through hungle canopy (Bendix-63); general references on micrometeorology (Sutton-53) (Geiger-57) and chapter on micrometeorology in Handbook of Meteorology. Further references on air, weather and climate include (Napier) (Gerson-55) (Stephens-52) (U.S. Smithsonian Institution Tables) (U.S.A.F. Air Weather Service Tech. Reports List-1963).

Illustrative of data on chemical substances produced from equipment, etc. are those of (Arnest-61) on submarine atmosphere contaminants. Similar observations could be made, but do not seem to be repeated for chemical products of personal equipment - from weapon lubricants, power source fuels and exhaust, clothing, garbage.

III. Physical Signals in Environment, and Their Transmission.

Detection of physical attributes and signals of man, discussed in Sections C and E, require knowledge of corresponding environmental properties. For analysis, sources are cited below on electromagnetic properties of bioenvironment, air and terrain; sound, vibration and electrical and magnetic fields of earth.

a. Electromagnetic Radiation

Many sources of data are available on space based (image pattern) and time based (movement pattern) electromagnetic properties of environment, over the spectrum from RF to gamma, for self emission, reflection and scattering, and transmission.

1. Bioenvironment properties

Faunal populations have been photographed and studied from the air (Buckley-57); and animals and plants photographically compared in visible and infrared for fall versus winter color. (Maniffen-53), maps of color regions of the world (Chambers-56), visibility in U.S. forests (Drummond-56), conditions in tropical rain forests (Richards-52), and military geography data (Mason-57), and alteration of foliage environment by chemical means (Coates-63) represent other information sources.

Spectral reflectance data are available - visible and infrared measurements include 400-650 millimicrons (MU) with some 710-900 MU, at low altitudes, for wide varieties of terrain, identified in 300 categories, set up in 11 basic types (Krinov-47) (Penndorf-56); 500-3000 MU aerial spectra for trees and groves (Martz-56); 400-1000 MU leaf and soil sample measurements (Keegan-56) and Canadian conifer spectra (Hindley-57). In extension into ultraviolet, 250-2000 MU data are at hand on rocks and vegetation and changes after root damage (Dwornik-E. R. D. L. -62).

Other animal color studies by biologists include (Pycroft-25) (Stephenson-46) (Fox-63); camouflage (Thayer-18), compare this with combat soldier camouflage study (Humphreys-62); adornment (Hingston-33), and adaptive coloration (Cott-57).

2. Radiation transmission by air.

Observation remotely (e.g. paths up to 1 Km.) of some electromagnetic radiation contrast property of humans, from radio to gamma spectral regions, requires knowledge of air transmission obtainable from the special sources of data set down by spectral region below. Other general sources include U.S.A.F. Handbook of Geophysics for Air Force Designers, Survey of Radiation in the Air (Shaw-58), and of absorption of sun radiation (Dickson-53).

In the Microwave regions air does not uniformly transmit; for absorption at 8 millimeters see (Nicoll-51); and for 8.6 mm. transmission in 3-12 mile air paths see (Tollbert-53). Other marked absorption bands exist at 1.0 and 1.64 mm., with better transmission at 1.3mm., 2.1 mm., 3.0 mm. and 1 centimeter. Chief absorption is due to oxygen (Meeks-63) and water vapor. See (Rogers-51), for solar millimeter radiation attention see (Theissing-56). These are only illustrative examples.

Infrared transmission in air is good in a few "window" regions (e.g. 1.05, 1.25, 1.7, 2.3, 3.75-4.25, 10 microns (U)). For the good water absorption data 1-10 U see (Wyatt-62); and 0.8-1.3 U (Schotland-62A), 0.4-2.3U for long air paths (Knestrick-61) and in near I.R (Howard-50); and far IR (Elasser-38) (Cowling-43). For CO_2 in near IR see (Howard-50). For other IR data, to 1U see (Bayley-62); to 3U (Curcio-61); and others (Howard-G.R.D.) (Elder-53); (Hilsum-48); (Dunkelman-52) (Larmore-56).

In the visible region air is a good transmitter. See the atlas of air absorption, 5400-8520A (Curcio-55); scatter data of 0.4-3 microns (Curcio-61); long path data 0.4-2.3U, (Knestrick-61); the good study of 30-10,000 Angstroms (A) absorption coefficients (Bayley-62), also others on air attenuation (Deirmenjan-52) (Stewart-52); slant visibility (Goldberg-52); and contrast reduction (Duntley-48); visibility biblio (Weiner-52A).

In the ultraviolet air transmits moderately well to 3000 A., below which ozone if present will absorb (2200-3000 A.). Transmission is poor below 2200 A. due to water, O_2, CO_2, N_2 absorptions. Data from 100-3000A. are given for these substances in good studies (Holland-62); and from 30-10,000 A. (Bayley-62). See data on scatter in the middle UV (Ban); extreme UV properties of oxygen (Aboud-55); water vapor (Watanabe-53A); (Johannin-Giles-54), and other data on specific gases (Watanabe-53B) and air (Hilsum-46), (Dunkelman-52).

In x-ray and gamma regions, air is essentially opaque, unless extreme energies are involved, as at 10^{-4}A.(for 100 MEV gamma). See x-ray mass absorption coefficients information (Allen-52), and the various special weapons effects handbooks for much more comprehensive data in this region.

3. Radiation properties of terrain

For low frequencies see radar reflection data on natural surfaces by (Cosgriff-Ohio State U.) and (Newbry-60), (Kinsman-62) illustrative of vast number of available reports. For terrain responses to 8 Kmc., see (Morrow-62).

For infrared properties, see 1-6 micron spectral emissivity (Fredrickson-57), showing radiation below 3U chiefly reflected sunlight, and that from 3-6U thermal emission. His observations of rapid minor fluctuations in surface temperature can offer a possible factor of contrast relative to man. For contrast "washout" by IR background, see (Fredrickson-59). For other IR data, see the infrared symposia (IRIS) periodicals sponsored by Navy; also specs on proposed IR spectrograph devices for lunar and planetary soil composition analysis (Lyon-63).

For other spectral background data, see (Vanderhei-56); desert spectral reflectance (Ashburn-56); Nevada test soil reflectance (Hillendahl-58), the Project Michigan literature, and Project SATAN data (Sensors for airborne terrain analysis).

4. Other sources of data

Other environment radiation is described including sky background radiation measurement (Graboski-61); infrared (Bell-56); radio noise from chemical explosions (Cook) (Kosky-54) (Takakura-55); jungle radio communications (Ambera-62).

Properties of materials versus radiation will be helpful in assessing environment or human artefact emissivities etc. Some sources include: materials emissivity and reflection (Pratt and Whitney-60) (Weber-59) McDonough-60) (Hosmer-53) (Beltran-61) (Blau-58) (Holladay-60) (McMahon-50) (Gordon-56) (Bell); (Crowley-59). Additionally, on IR properties (Maki-60); 4-13U (Wood-60, 62), 2-15U (Reid-59); on microwaves and water (Posener-53); on UV and x-ray (100-1500A.) (Fivens-63); visible region (Barber-63) (Pyrne-54).

Other data on measurement techniques include: reflectance (Dunkelman-60) emissivity (Cairns-60) (Harrison-60) (Bell-55); source (field black body) (Larocca-58); other (Schotland-62A, B).

b. Sound and Vibration, Background and Transmission

For earth surface natural background acoustic noise see (Wescott-63); for other human-generated environment noises see (Bolt-52); also close quarter ship board noises (Bishop-53), and weapon noises (Doelling-59). For animal sounds see (Lanyon-60); and especially for insect sounds (Pierce-48). Air absorption in low audio ranges is discussed by (Nyborg-55) and by (Horiuchi-57) who also considers humidity effects, ultrasonic absorption (over 15 Kc/S) by (Herzfeld-59); for other air and components data such as oxygen, see (Kneser-33), for effects of temperature and water vapor on N_2, O_2 air absorption, see (Knudsen-53). For Audio Sound transmission and reception under combat conditions see (Waring-46).

For earth seismic background environment and geography see (Griffin-63). More general data are available in a vibration and shock environments biblio (Hercules-62); in the Shock and Vibration Symposia reports from the Naval Research Lab, The University of Michigan's Project Michigan work on combat surveillance (especially on seismic signatures of human devices). For other related data on acoustic sources see biblio of (Thurston-59); data on underwater sound background study techniques (Marsh-61) (Barber-62) and work of Melpar on personnel sensing.

c. Electrical and Magnetic Field Background Phenomena

If any electrical and magnetic attributes of man are to be sensed remotely by non-radiative methods, the sources below will provide some data on natural earth background conditions. Also worth looking into are possibilities that detection might be accomplished by man's distorting these electric and magnetic patterns of natural origin or others deliberately induced in ground and air.

1. Earth currents

Signals measurable vary from 10 MV./Km. at low latitudes to 400 MV./Km. at high latitudes and are measured over a bandwidth from d. c. to radio frequencies; average values on which various pulsations are superimposed (Ward-O. N. R. -62) affecting magnitude, direction and sense, with low frequency variations (under 1 C/Sec.) highly correlated with geomagnetic disturbances (Ungstrup-62) (Hessler-59) (Linehan-61) (Fleming-39), also changing with season, temperature, humidity, lightning, etc., and in presence of industrial devices, underground water.

Earth currents are typically measured with electrodes placed in ground, in North-South or East-West pairs, in one measurement 1000 feet apart (Fleming) (Hopkins-60). Proper electrodes must be chosen to avoid contact potential, polarization (Law-59) local effects.

2. Electrical Resistivity of Earth

This is separately measurable and contributes negligibly to earth current measurements. Typical resistivity measurements can be made with a known current applied to outer pair (100 feet apart), and EMF measured on inner pair, with electrode commutation to compensate for polarization, etc. A nominal value of 5 million ohm-centimeters (Fleming) may vary widely with moisture and other surface conditions.

3. Air-to-Earth Current

This is measured along a vertical line, between plate on ground and plate on horizontal wire above (Kasemir-51) or pair of horizontal plates in air. It is about 3×10^{-16} amperes/CM^2 close to ground, requiring sensitive electrometer equipment (commercially available.) This current varies with height (Chalmers, p. 142) (Schonland-53).

4. Other Air Properties

Air ionization (Israel-51) about 1. 8 ion pairs/cc/Sec. close to ground, chiefly derives from ground radioactivity (K^{40}, radon gas) (Schonland-53), with contribution by cosmic rays (Chalmers-57). This varies rapidly with altitude. Charge separation in air can be found after rainstorms and various atmospheric disturbances (L. Smith-59) (Friberger-61). Also as of this date, intense air ionization may be induced remotely, in a small volume of air, briefly, by a pulsed laser beam (see popular account in July, 1963 Scientific American).

5. Geomagnetism

Classical data on steady pattern (Fleming-39) (Rooney-49) are augmented by new studies of origins, fluctuations (Law-59) (Miles-62). For details of rapid changes of a few gamma (10^{-5} gauss) occuring with periods of o.1 sec. to 10 minutes, see (Provazek-61), and the elegant work of (Linehan-61) with proton precession and other magnetometers, getting background data for Air Force, in very sensitive fixed field measurement arrays which could lend themselves nicely to experiments on disturbances induced by presence and movements of man near the sensing elements.

E. SENSING AND DETECTION OF HUMAN ATTRIBUTES

I. Introduction

This survey of specific techniques for sensing the concealed man by means other than the unaided senses, is based on consideration of those human signal properties previously discussed(emission, reflection or its transformations, influence or proximity effects). To be observed, such signals must cross the intervening space to the observer, and not remain confined or in the vicinity of the body of the target.

First emphasis here considers the specific physical or chemical variables to be sensed, and the description of various principles of physical, chemical, or biological nature for doing this. Both passive sensing and active means(after illumination of the target)are considered. Special attention is paid to the problem of measurement of very low levels of signal, and trace quantities of material from humans.

Source data given here(and also available from many commercial and military surveillance study sources), must be further examined in a systems analysis for each phenomenon which could provide a data link, to adjudge: whether a physical possibility for use of the sensing effect exists; and what prediction can be made at present or for near future conditions about sensitivity, response time, specificity, other acceptance or discrimination properties comprising figures of merit. Further analysis of signal separation from noise(chemical, physical, or biological) and of recognition techniques, can consider methods of using intrinsic properties of the primary sensor or auxiliary devices to allow: pattern recognition, in space (radiation image), in time(eg seismic signature), for concentration(multi-substance concentration profiles), in relation to reference patterns stored within the instrument;and to allow synchronous detection(as with active systems), autocorrelation analysis, etc. Even in exploratory analysis of principles, the reader must keep in mind the ultimate problem of the use in the field action environment, and related factors of use burden(power, size, weight, mobility reduction, attention diverted from other tasks, etc.).

The material which follows will cover Biosensing(use of living material as transducer for various variables), Physical sensing, and chemical analysis methods.

II. Biosensing(Living Tissue as Detector).

a. General Comments.

The serious consideration by anyone of the use of living material as a sensing transducer requires demonstration:that specific variables can be sensed, that reproducible and stable input/output relations exist, that output signal can be conveniently collected, that the material can be kept alive and functional without inordinate effort. Only then can biosensing techniques be considered seriously for comparison with other chemical and physical instrumentation. using measurement engineering criteria of range, bandwidth, sensitivity, bandwidth, resolution, etc.

Demonstration of plausibility and utility has been carried out by many. At this point in time much is known about the living sensing process. A great deal of physical and engineering insight is being applied to describe quantitatively the transfer characteristics, internal mechanisms of the biological communication process and of sensors; and to apply knowledge obtained from observation of the living sensor process to physical design.

For general and good references on this, see:record of First Bionics Conference, Dayton, 1960, in Report # USAF-WADD-TR-60-600;also Second Bionics Conference(Bernard-62);a Third Bionics Conference held also in Dayton 1963 will be in print shortly from WPAFB. See also:Abstracts, 7th Annual Meeting, Biophysical Society, 1963;

Studies have been made on a wide variety of living receptors, sensing mechanical quantities(sound, vibration, acceleration, strain, force), radiant energy(UV, visible, IR), thermal and electrical variables, etc. They show that living receptors have many unique attributes; for some:extreme sensitivity(to quantum limits for photoreceptors)(to a few molecules of chemical substance for some chemoreceptors);they are "microminiature", are self-generating(requiring no applied power, just metabolic fuel); and have a pulse-like output, pulse-rep-rate modulation, with pulses which can be counted and stored.

Use of living material for reproducible sensing of environment is not limited to special sensory receptors;as will be described later, many types if isolated tissue may serve as transducers; and these may be employed at diverse levels of biological organization(cell batches, tissue, isolated organs, etc.).

For quite specific data usable for biophysical analysis on sensing processes, consult the following analytic studies:comprehensive book(Rosenblith-62)on sensory communications; sensory energetics(J. Gray-52), comparative survey(Bullocl-53)(Granit-55), internal mechanisms(Katsuki-61)(Kennedy-62), other biophysical reviews by (Davis-53, 61)(W. Loewenstein-59, 60), (Makarov-61);also biological signal and noise study(Molyneux-63), signal detection(Hack-63). All of this work was done as basic biological research, not applied to instrumentation. For biblio on various living sensors applicable to physical design , see(Kornfield-61)and for analyses of application to BW detection, see Kornfield-62A, 62B, 63).

For information on the ease with which sensor tissue output data signals can be collected, for specific data on the related electrophysiological measurement methods, see(Ford-57), (Bures-60)(Cameron-60)(Davis-59), and for electrodes, see(Sosnow-61). See also the description of methods in papers cited on isolated receptor preparations in the pages which follow. For the detailed physico-chemical analysis of the production of bioelectric energy and its extraction from various living sources, also see(VanWinkle-62).

For a discussion of tissue culture and living material maintenance techniques, see(Cameron-60)(Merchant-60)(Parker-61)(White-61)and the large biblio of(Murray-53);for insect tissue culture, see (Loeb-57)(Martignoni-60).

For other good biological information sources relating to sensors, for comparative physiology, including senses(Prosser-50, 61), sensory physiology(Von Buddenbrock-52); comparative physiology of the nervous system (Koshtoiants-60);insect nervous system(Roeder-58), and his insect physiology(Roeder-53);reptile sensors(Kahlman-32)chicken skin sensors(Winkelmann-61)mamalian skin nerve endings(Waddell-55), other skin nerve endings(HinChingLiu-62);bee communications(Haldane-54)animal navigation (J. Carthy);for drug use elucidating sensory process, see(Habgood-52), (Buchthal-54).

b. Specific Chemoreceptor Studies

1. Comments

The field of chemoreception is sampled in detail over the next several pages. There is included information on many specific studies on whole animal behavioral and electrophysiological measurement, and in isolated preparation electrical output studies. About 25 species of insects, and about 50 other animal species are included, where specific information was published, describing a receptor structure, and/or its sensitivities have been published. Other detailed sources are listed for data on dog smell sense and tracking, human smell and taste sense, and smell and odor information.

Chemoreceptors have been highlighted because of their phenomenal sensitivities and specificities, and multi-substance analysis capability, without counterpart in any physical apparatus today. We have set down the specific chemical substances used as stimuli for most of the experiments listed. From these, the reader may select those preparations for further experiment; which come from animals available and indigenous to the region of interest, with specific desired chemosensitivities, and yielding convenient experimental preparations.

For a few individual chemoreceptor electrical output measurement studies, not listed in the tables, see (Hodgson-55B), (VonBuddenbrock-55B), and for administration of trace chemical stimuli by microelectrophoretic techniques to individual chemosensing cells(Baumgarten-63).

Animal scent production and its sensing deserves some comment. This is a "scent communications system";a large number of species produce specific materials(in many cases chemically identified;eg. for beaver, over 100 substances--see Hardy-48), which are synthesized, stored, and released from a specific gland structure, so liberated into air environment, or depos-

ited in environment, there to be sensed generally by the same species, with attendant behavioral response, related to food finding, warning, territorial mapping, navigation, sex, etc. The scent mechanism has been best studied in insects, where phenomenal sensitivities to known substances have been found(eg .30 molecule threshold to specific substance in cockroach sensing). The airborne substance has been identified , and chemically synthesized, the chemoreceptor properties related to it studied and the whole effort exploited in the development of insect attractant insecticides, discussed elsewhere in this report. The products of animal scent glands have also been studied by the perfume chemist and industry, to obtain components for their blends, from such animals as beaver, civet cat, muskrat & shrew, although in their case without knowledge of the animal sensors. Except for these classes of studies, the literature of ecology is devoid of accurate description of the scent communication process.

In the chemoreceptor lists which follow, of insects and other species, we have included additional data on the existence and description of scent production for many species, for several reasons: it represents a chemical substance acting as "noise" or unwanted signal in the environment to which the animal is indigenous; also from the presence of a scent organ in a species one may confidently predict that a specific chemoreceptor responsive to that substance exists in that species, even though no explicit information has been set down on chemoreceptors for that species; finally in many cases the scent substance chemical components from a given animal may have their counterparts in some product of man(sebum or apocrine gland componentproduct--which have been claimed to be types of "scent communication" substances--See Schaffer-37, Wheatley-51). Experiments with the chemoreceptors of that matchup species may be most profitable in quest for a human detection element.

2. Insect Chemoreception

Many good quantitative studies on a diversity of species, sampled herein, show the unique eligibility of insect chemoreceptors as controlled isolates for biosensing, because of experimental convenience (of hardy preparation, ease of individual receptor isolation, exposure to stimulus and single nerve response signal collection). The readers' selection of one or more insect tissues as experimental candidates for human substance sensing can derive from consideration of regional habitats of specific insects, their attraction to human hosts, and the match-up between the diverse sensitivities studied and human products. Specific receptor studies also including notes on scent substance emission are set down below.

The most promising of these for further work from the standpoint of knowledge of stimuli, isolation and measurement procedures are preparations of the silkworm moth, blowfly, butterfly and bee.

Chemoreception in Specific Insects

Ants: For direct study of olfaction, see (Marcus-46). Other studies in response to scent substances are cited below.

Scent production by various glands (Wilson-59, 62), with chemical factors catalogued (Wilson-58); produces alarm and digging behavior in various species (Wilson-58).

Bees: For early study on chemosensing by antenna and tarsus see (Marshall-35); for taste perception (VonFrisch-34), chemosensing in general (VonFrisch-50); behavior in distinguishing companions (Kalmus-52), smell sensing (Gubin-57) (Schwarz-55) (Ribbands-55); and a definitive paper on isolated antenna electrophysiological chemoreceptor measurement see (Boistel-56).

For scent glands, see (Frings-44) (Gary-62). For specific known products of queen, serving as attractants see (Gary-62). For attractant test methods see (Woodrow-58); for Bumblebee scent trail description see (Wynne-Edwards-62), and for good recent data on scent substances from bees see (Jacobson-63A).

Beetle: For early beetle olfaction, see (Richmond-27), also olfaction affecting host selection and oviposition (Crombie-41). In other behavioral studies quite early the very high sensitivity ($1{:}10^7$) to skatole demonstrated by (Abbott-27). For carrion beetle orientation to odors see (Dethier-47C).

Butterflies: For specific receptor studies; leg, sugar sensitivity see (Anderson-32), tarsa receptor to sucrose sensitivity by neural fiber electrical measurement, and in same (Takeda-61) receptors stimulation by electrical current to examine receptor internal mechanisms (Morita-59).

For scent emission and sex attractants isolated by (Inhoffen-51), see (Butenandt-55) (Gotz-57).

Cockroach: For early taste threshold studies on electrolytes and sucrose and the related receptor locations, see (Frings-46A). For diverse studies on cockroach chemoreception see Q.M.R. and E.C. Natick list of publications.

For scent substance sex attractant sources, see (Wharton-57), working over several years; for composition, see (Wharton-61), and effects of radiation and other noxious stresses, identification of one substance as 2-hexenal (Roth-56) and from a tracheal gland, paraquinone (Roth-58). Phenomenal 30 molecule threshold sensitivity (10^{-20}gm) of roaches to their own chemically identified scent substance is discussed by (Jacobson-63A).

Flea: Sensor physiology (Dethier-57B).

Flies:

Blowflies: Much exact work on in put/output relation, specific sensitivities, internal mechanisms has been done on these, chiefly because of their experimental convenience of access. For early chemotropic behavior studies, see (Hobson-32) (Abbott-38) (Craff-45). For other response to specific substances, for alcohol series, see (Dethier-47B), aliphatic aldehydes and ketones (Chadwick-49), (Dethier-54), various carbohydrates (Hassett-50) (Hodgson-56, 57),

organic sulfur (Cragg-50B). For properties of specific receptor sites, for tarsal receptor sensitivities see (Chadwick-47); for various contact chemoreceptors, see (Dethier-55), and olfactory receptor types and responses (Dethier-52). For recent precise sensor observations including electrical output signal measurement, on labellar receptor responses, see (L. Brown-62), for water taste (Wolbarsht-57) (DeForest-61); protein (Wallis-61), NaCl (Wallis-62), and for temperature effects on receptor mechanisms (Dethier-58).

It is seen that even where extensive studies have been made on a given species, systematic exposure to all major chemical groups for threshold study has not been done. Along with such experiments can be tested thresholds to fractions of sweat, sebum, urine or feces of humans in isolated preparation studies.

Flesh fly: For smell sense see (Steiner-32); for taste, sucrose threshold see (Frings-54).

Fruit Flies: for chemoreception see (Begg-46), response to animal excrement (Harrison-54); and to fermenting banana products (Reddle-63). For scent output (male sex attractants see (Ripley).

Horsefly: for contact chemoreceptors (female) see (Frings-46B).

Sawfly: For scent substance production and chemosensitivity, see (Coppell-60) and (Casida-63), and especially rapid response of pine sawfly to nanogram sex attractant levels (Jacobson-63A).

Screw worm fly: For early chemosensitivities, including urea, see (Abbott-28). For an account of scent production and sex attractant studies, see (Jacobson-63A, B).

Walnut husk fly: For scent substances and their properties see (Barnes-58).

General comments on many other fly studies: For olfactometers, see (Eagleson-30), for responses of slies to cattle dung and urine, see (Chorley-48).

Grasshoppers: For antenna and flagellum receptors see (Slifer-55, 56).

Locust: For specific recording in nerves from in antenna chemoreceptors, see (Uchiyama-56).

Louse: For early chemoreception studies see (Pick-26), later (Dethier-57B).

Milkweed Bug: For recent atenna and flagellum receptor data see (Slifer-63).

Mite: For chemoreceptor electrophysiological studies, see (Elizarov-62), for clover mite humidity sensor, see (Winston-62), other studies (Dethier-57B).

Mosquitoes: For chemoreceptors in yellow fever mosquitoes, see (Frings-50) (Owen-61, 63), for their antenna and flagella organs (Slifer-62), for mosquito

antenna sense organ survey, see (Stewart-63). For other chemosensitivities in general (Willis-47), amino acids (Schaeffenburg-59), odors attracting for oviposition (Crumb-24) and attraction by odors of Anopheles to animals (Podomodvinov-42). Chemosensing attraction to humans has been studied by many (Rahm-57A, B, 58A, B) (Laarmans-55, 56); with specific chemical factors considered by(A. Brown-56), those components of sweat (A. Brown-51, 61B) (Thompson-55) (Owen-63), including lysine at low concentrations (Brown-61B) and other amino acids (Brown-61A). Attraction by human CO_2, etc. is considered by (Willis-48) (Reeves-53), and temperature and humidity influences by (Smart-56).

Moths:

Gypsy moth: Best chemosensor studies done in relation to its scent substance (female sex-attractant), "gyptol" isolation (Acree-53), composition analysis by chromatography (Acree-54), subsequent synthesis of fractions, and use in "attractant" insecticides such as the Department of Agriculture's "gyp lure". Male chemosensing thresholds of 10^{-13} gm. stated by (Jacobson-63B).

Silkworm moth: Receptors of larvae intensively studied, measurements of specific chemical stimulus by (Morita-59B), and electrical "generator potentials" measured by (Morita-59A) (continuous E. M. F. produced intracellularly in response to the chemical stimulus, and giving rise to the spike impulse output signal train seen on the receptor nerve). For carbohydrate sensitivity, see (Ishikawa-63), and for citral, lenalyl, terpin compounds see (Hamamura-61). Good isolated antenna preparation studies with various chemicals and with electrical output measurement, bu (Schneider-57), including exposure to one kind of scent substance emitted by this organism (Schneider-56).

For other scent substance description see (Seguin-54), and series of papers by (Butenandt-47, 62) who has defined its sex attractant function, its chemical nature.

Other Moths: For comparison of olfactory specificity of emitted-scent; sex-attractants in different species, see (Schneider-62), with further isolation by (Kecker-58) and bioassay of synthetic scents by (Block-60). For giant saturnid moth sex attractants, see (Rau-29) (Dethier-47A), early references in insect scent.

Tick: For smell and attraction to animals see (Philip-53), on chemoreceptor function see (Dethier-57B).

Tropical Water Bug: For male scent substance composition, see (Butenandt-57). Since this is used by some in S. E. Asia as a food spice this scent, if carried by a native of the area, may be detectable remotely in extremely low concentrations, its analogue of isolated chemosensing preparation from this insect.

Other Data Sources on Insects: For excellent annotated biblio on smell in insects, see (Hocking-60); for comparative physiology (Frings-48); receptor ultrastructure (Dethier-68B). For chemoreceptive behavior studies see (Brown-28) (Ingle-43), (Dethier-57A) also in parasitic insects (Thorpe-37, 38, 39). For electrophysiological measurements, see (Chapman-53) (Roys-54), Takeda-59), for internal signal conversion (from chemical imput to electrical output) see (Hiromichi-59) (Morita-59A), and for other mechanisms (Dethier-48, 51, 56A).

On insect scent and attractants, see excellent recent reviews (Jacobson-63B) (Karlson-50), and older material (Cattreau-05) (Kettlewell-46). For specific receptor loci and sensitivities (Schwink-55); for certain specific attractant classes (e.g. amines, fatty acids, sulfides, NH_3) see (Green-60B).

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3. Chemoreception in Various Other Animals

To the sample of specific studies cited below on chemosensing, scent production and communications, apply the same criteria cited under "Insect Chemoreception" to select hardy tested preparations for further experiment in sensing human chemical products.

Promising animal chemoreceptor preparations considering only the superior knowledge of tissue isolation, measurement, and understanding of some stimulus properties will be seen under Cat, Crayfish, Hamster, Rat, and especially Frog and Rabbit.

Alligator: For olfaction, see (Gestland-61). Scent glands "musk" secretions see (Foster-34), (Hardy-49A).

Anteater: For taste receptors see (Kubota-62).

Arthropods: For chemoreceptors terrestrial and fresh water forms, see (Hodgson-58B).

Badger: For scent glands close to anus, in some, in a pouch under tail, see (Hardy-49A) (Neil-48).

Beaver: For scent glands between anus and genitals see (Schweisheimer). For composition of products of this "perfumery animal" see (Walbaum-27) (Rosenthal-28) (Lederer-43) (Naves-34, 47) (Givaudan-49) (Arctander-60), for 100 constituents identified see (E. Hardy-48).

Birds:

Condor: Smell (Gill-04).
Duck: smell (Nolte-30) and scent production (Bang-60).
Gray Goose: smell (Best-13).
Ostrich: taste and smell (Gillespie-22).
Quail, Bob White: chemosense discrimination (Frings-52).
Turkey, Wild: smell (Caton-70).
Vultures: chemosenses (Bang-60) (Leighton-28) (Lewis-28). Scent gland and "musk" production musk glands (Bang-60).

For other general data on taste and smell see (Portman-61) (Soudek-29); smell (Zahn-33) (Taverner-42) (Miller-42) (Bartsch-43) (Bang-60); for conditioned reflex studies see (Walter-43).

Boar: For scent glands and products see (Pocock).

Cat: Taste fibre response spectra (Cohen-55). For scent substance composition from civet cats see (Bennett-29) (Hardy-47A) (Naves-47) (Treatt-12) (Vandenput-37) (Arctander-60) (Bedoukian-51) (Dubois-59). For relation between scent production and sex behavior see (Stoller-61).

Chimpanzee: Smell (Blackman-47).

Crabs: Smell and taste receptors in mouth in one species (Cheesman-22); in horseshoe crab chemoreceptors (Barber-56).

Crayfish: Chemosensory responses to NaCl, glycine, glutamic acid (Hodgson-58B).

Crustacea (various): For chemoreceptors (Laverock-63); for scent substance and sex attractants (Forester-51).

Deer: For common deer smell sense see (Caton-70). Musk deer furnish an important source of perfume components. For scent glands, in musk deer, between naval and penis see (Naves-47). For those near eyes, hocks, toes, see (Stoller-62); for secretion see (Durvell-23) (Perry-25) (Sagarin-45) (Naves-47) (Bedoukian-51) (Schweisheimer-56) (Wynn-Edwards-62) and (Owen).

Fish:

Carp: For taste see (Konishi-61).

Salmon: For smell and taste sense, see (Hassler-57); and for repulsion by human skin serine see (Idler-55).

Other fish: For discrimination of stream odors see (Hassler-51).

Fox: For scent glands on feet, pads, near anus, and products, see (Mivart).

Frogs: Experimental convenience, including sensory access, has spurred much receptor work; on taste receptors, single unit studies (Kusano-60) (Casella-61), including response to NaCl and sucrose (Kusano-60). Acetic acid (Kimura-61B). On smell receptors: olfactory nerve signal collection (Kimura-61B), receptor system microanatomy (Altner-62) response to cations versus anions (Yamashita-63).

Goat: (Alpine) For scent gland and products see (Bedoukian-51).

Hamsters: These provide convenient preparations allowing good receptor studies for taste receptor, microelectrode measurement, see (Kimura-61A).

Invertebrates: for chemoreceptors in general see (Hodgson-55A).

Jackass (Laughing): For taste and smell receptors see (Pocock-12).

Lion: For smell see (Oliver-30).

Martin: For scent glands (anal) and dispensing of secretion on twigs, see (Portman-61).

Mouse: For olfaction detailed behavioral and physiological studies, e.g. smell induction of neurohumoral changes affecting estrus,etc. see (Parker-61).

Nereis: For chemoreceptor responses to alcohols, see (Case-62).

Newt: (Spotted) For smell sense see (Copeland-13).

Opossum: For study of isolated olfactory epithelium, recordings on isolated nerve and essential-oil stimuli, see (Beidler & Tucker).

Rabbit: Many good olfactory studies for "electro-olfactogram" (recording in olfactory nerve tracts), see (Moncrieff-61); for study of sensor smell and taste enzymes, see (Varadi-51), for anal scent glands see (Owen) and for relation of scent production to sex activity, see (Cougard-47).

Rat: For taste receptor microelectrode studies, see (Kimura-61A).

Scorpion: for chemoreceptors, see (Alexander-57).

Sheep: For scent gland location and output, see (Hardy-49B) (Bedoukian-51).

Shrew: For lateral scent glands and territorial mapping behavior, see (Pearson-46).

Skunk: For scent glands and substances, in U.S. and European polecats, see (Hardy-49A, B).

Snake: For "olfactory" cells on tongue, see (Smith-51); for anal scent glands also see (Smith-51).

Spiders: For chemosensors, see (Abbott-27).

Toad: For direct electrical measurements on olfactory epithelium, see (Takagi-60, 61).

Tortoise (American): For scent glands see (Hardy-49A).

Turtle: For mud turtle chemosensors, see (Carr-51) (Poliakoff-U. S. S. R. -30); for musk turtle ventral scent glands, see (Risley-33).

Viper: For smell sense, see (Bauman-27, 28).

Weasel: For scent gland substances produced and "musking" scent deposition behavior, see (Neal-48).

Whales: For smell sense, see (Kellogg-28).

Wireworm: For chemosensors, specific stimulus studies, see (Crombie-47).

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4. Dog Chemoreception

Dogs have proven invaluable in intrusion detection, tracking, and other observation of humans, are currently under laboratory and field study, and use for special operations, by various Defense agencies. Since our primary concern was with basic sensing processes, we have assembled here a small fraction of published material on dog tracking of humans and related subjects as a source for further analysis by the reader in our context of discussing biosensing by whole animals and isolated preparations. Most of the published work, though emerging from the pen of dog handlers of proven capability, is inexact and only generally descriptive, where factors of specific human attributes, environmental modifications of these and precise conditions of dog response are concerned. Most of the references were available and seen in the New York and Boston Public Libraries, ard are probably in the Library of Congress.

For specific comments on human tracking (Budgett-37) discusses ranges, loss of track with time, masking by vegetation (e.g. by mint, willows), and enhancement by vegetation, in grass. Tracking on crushed vegetation trails is also discussed for bloodhounds by (Whitney-47, 55). (Dr. Whitney, an outstanding authority on dogs, is in Orange, Connecticut.)

For detailed discussion of skilled tracking (including New York State Police work) on new and old trails (100 hours) and long distances, see (H. Davis-56). He expresses conviction that dogs pursue traces of skin products, reaching the ground diffusing through shoes, etc., and speculates on specific chemical substances involved including such fatty acids as caproic and propionic. He describes tracking experiments using traces of known substances deposited on ground including acetic acid and salt. For similar experiments with deposited chemicals, (e.g. iso-valeronic acid) and tracking responses similar to those for humans, see (Budgett-37).

Major L. Davis of K-9 Training Agency, at Hyde, Maryland (near Baltimore), who has trained dogs for many diverse tasks, and did work on CW detection by dogs, suggests in conversation that the skin product sebum is the key factor in the tracking of man.

Simple, but definitive experiments could be conducted by any of these good dog tracker trainer groups cognizant of the chemical factors problem, using sebum of man deposited on ground or dispersed in air in various concentrations. Sebum used could be freshly obtained, from various people, or allowed to undergo normal skin bacterial decomposition, and could be used whole or in fractions obtained by chromatography (mentioned elsewhere in this report) to define exactly which chemical factors, if any, from sebum are the key ones in human tracking.

For other studies on human tracking, see (Schmid-35), for human individual differences (Kalmus-55), and for dog breed capability differences, see (Schnitzer-62).

For other smell sense descriptive writings, see (Grassi-89) (Romanes-87, 90) (Binet-96) (Johnson-14) (Henning-19) (Bozelli-21) (Buytendijk-21) (Rudolph-23) (Warden-28) (Cramer-41), and for hounds (Rudolph-23) (Whitney-47, 55). For conditioned reflex studies on smell and taste, see (Allen-37) and for direct electrophysiological measurement of chemoreceptor (taste), see (Anderson-50).

For other general discussion of military uses of dogs, see (Meguian-20) (Going-44) (Behan-46) (Gorman-54) (Downey-55) (Waller-58) (Derringer-58) (Clapper-61), including study for certain CW agent detection (Davis-62). General narratives on police uses include (Diederich-09) (Gross-12) (Craig-24); utility of hounds (Knoche-57) (Chapman-60), and smell sense (Lohner-26) (Schmid-35).

For descriptions of dogs, by type, for hounds, see (Sigling-28) (U.S. Lib. of Cong., Div. of Biblio.-26) (A. Smith-32) (Chapman-33) (Stancko-54) (Watts-55); and bloodhounds by (Oliphant) and (Whitney-47, 55) (Appleton-60); beagles (Denlinger-56); Doberman Pinschers (Denlinger-53).

For other general related discussions of dogs, see (Menzel-29, 30) (Mason) (L. Whitney-33) (Lyon-50); also dog encyclopedia (H. Davis-56); and animal behavior descriptions (J. Scott-58) (Dorn-57).

5. Human Chemoreceptors

Human smell and taste sense data likely will provide very little direct contribution to solution of the human detection problem. But the reader may find the few sources cited here of value, in considering human thresholds compared with animals having special sensitivities, factors modifying smell sensitivity (and possibilities of enhancement of human olfaction), and what little data there are on human smell perception of other humans.

Olfaction: For nose structure and function, see (Holmes-49) and Proetz's "The Nose", about 1954. For many threshold values see (Spector, p. 327-56), (Hessel-61), (VonSkramlik-48), for mixed organic chemicals (Rosen-62); absolute intensity judgment (Engen-59), threshold theory (Davies-55), olfaction information processing (Wright-63), and other odor evaluation (Merritt-59, 60, 61); (Crocker-52), (Amer. Soc. Perfumers-61). For "chemical analysis" by olfaction, see (Alekseevki-41). For multiple factor smell analysis, see (Hsu-46) and especially (Schutz-61). Using many human subjects and odorants the latter's multiple factor studies isolated 18 physico chemical variables associated with human olfaction most classically suggested, including radiation spectra, surface activity, vapor pressure, boiling point, heats of combustion, refractive index, etc. For odor versus composition see (Timmermans-54). For devices for presenting odor experimentally, see (Wenzel-48, 50), Battison-62).

For factors altering olfaction sensitivity and capability, drugs (e.g. menthol, strychnine, acetylcholine), see (Skouby-54), for industrial substances, (Eolian-60). For suggestive relationships to various sexual factors, to sexual activity (Podolsky-46), olfaction changes in conditioning with androgens and estrogens (LeMagnen-49) and relation to female secondary sex characteristics (LeMagnen-48), smell sensitivity to sex hormones and their metabolites (Klock-61). For defects in smell sense after injury, see (Leigh-43), changes with temperature of the odorous substance (Kerka-56), changes with altered physiological state (LeMagnen-50).

For human smell sensing of other humans; for geographic regional odors, for Europeans, see (Adachi-03) (Laloy-04A, B), for several groups, including Japanese, French, Balkan, see (Eller-41), for human odor individuality, see (Laird-35); (Lohner-24). For other human odor sensitivities, significance, and control, see (Haggard-41) (Neuhaus-61); for human "scent-producing organs" see (Schaffer-37); and for the production of odorants on skin in normal bacterial flora there, see (Strauss-56). On other odor problems related to man, on odors and shelter habitability see (Muraoka-61) (Traffalis-55); sanitary significance of odors (Earp-23); their detection in water (Fair-34); odor control (McCord-49); especially in (casualty) evacuation aircraft (Gee-51); various others including breath garlic odor (Haggard-35); fish odor (Mangan-59), and asthma induction by urine, feces, sweat (Vamis-47).

Taste Sense: : For basic concepts see (Johnston-55); chapter in Handbook of Neurophysiology (Magoun-61), Handbook of Experimental Psychology edited by S. Stevens in 1951; for compound evaluation techniques and flavor research, see (Krum-55) (Peryam-58); (Merritt-58, 59, 61), and for flavor physical chemistry see (Laymans-59). Information on human taste sense will probably contribute very little to selection and trial of other animal isolated smell and taste receptors, with human chemical products.

6. Other Specific Studies

For excellent biblio. on smell and odor, see (Airkem-52); for theories of smell, see (Jones-O. N. R. -53) (Foster-50) (Kluvier-58) (Beidler-57, 60, 61A); for enzyme theories (Kistiakowsky-50); other analyses (Middleton-56) (Mateson-44) (Bedichek-60) (Bronshtein-U. S. S. R. -50) (Beets-61) (Dravnieks-62) and new identification of physical variables (Tucker-63). For studies of smell epithelia (Baradi-57) including electrical activity of isolates (Ottoson-56); and of smell adaptation (Adrian-50). For regeneration of olfactory cells, see (Schultz-41), and old papers, on scent (Shepherd-Walwyn-26) (Bawden-01) (Hopkins-26).

Taste Sensors: For analytical papers on contact chemoreception, see (Beidler-54, 57, 60, 61A, 61C) (Bronshtein-50) (Roshupkina-54); for comparative description (Johnston-55); electrophysiological studies (Beidler-55A), on single fiber signal output (Zotterman-59) (Sato-60) (Kimura-61C), other measurement techniques (Hodgson-61). For physical chemistry (Ruben-62) including enzyme basis of taste (Koshtoiants-58) (Mateson-54); for CNS efferent control of sensor (Esakov-61); taste and smell enzymes in rabbit (Barack-5).

Interochemoreceptors: Within higher organisms, neural receptors have been identified, for osmotic pressure sensing in the head, for O_2, CO_2, PH sensing in carotid and aortic bodies, for glucose in liver (Russek-63). Others are suspected to exist, in the intestine (Baraz-61) and elsewhere, sensing at least those several dozen chemical variables of blood plasma known to be regulated at steady levels by homeostatic systems, responsive to stress of loading or deprivation of substances. If discrete receptors are found for high molecular weight substances (proteins, polysaccharides, etc.), amino acids, urea, these may be studied as isolated biosensing elements, to match human product output.

Other Work: For comparative physiology, see (Jahn-50) and for invertebrates (Keefe-62) and other "common chemical" senses, see (Crozier-16). For calcium relation to function (Lenhoff-59), reception in aqueous versus gas phase (Hodgson-53), for carboxylic acid cycle role in reception (Teng-61). For anatomy, (Clark-57) physical chemical factors in stimulation effectiveness of compounds (Ottoson-63),), and chemoreceptive regulation of animal feeding (LeMagnen-59). For a review of chemobiosensing in application to BW detection, see (Kornfield-62A, B, C, 63). For Air Force interest in enemy troop detection by physical analogs of olfactory techniques, see (U. S. A. F. Aerospace Med. Lab Procurement Office).

c. Chemosensing by Isolated Tissue Other than Receptors

In principle, all regions of a living organism have potential and actual responsiveness to chemical stimuli. In practice, tissue isolates have been prepared from most every organ, in many species, at levels of cell, tissue, organ, then exposed to chemical stimuli. For all tissue culture and life support means have been identified for easy maintenance of extended integrity. (Also some tissues can be kept in low temperature or chemical stored state for long periods.)

On various types of isolates, so supported, continous observation of overt response (readout) appears most practical by mechanical and electrical means, with straight-forward extensions of instrument engineering techniques. Observations on typical preparations illustrated show rapid responses and high sensitivities to wide range of known chemical substances.

Sensitivity augmentation is possible by proper conditioning of the animal from which the tissue was taken, as will be discussed. Some types of isolates include:

Living Skin: A few square centimeters, most easily obtained from frogs, can be set up as a membrane barrier in a simple hardy apparatus which keeps it alive and yields a large electrical signal change rapidly upon exposure to traces of a variety of known chemical substances. For experimental apparatus see (Scheer-60), (Ussing-60); for effects of specific trace substances, for example, for low molecular weight materials (steroids), see (McAfee-61); for response to high molecular weight substances (e.g. toxins from cholera organisms), see (Huber-60). Many other known trace chemicals also act to alter specific metabolic processes in this living skin, changing its permeability and ability to "pump" sodium and other substances across itself and against a concentration gradient, so altering observable voltages and "short circuit" currents always present and measurable.

Living Gut Strips and Segments:

Contraction events: A strip a few cm. long, from rabbit, or guinea pig ileal region of the intestine, easily set up in life supporting medium, contracts automatically, rhythmically, and will show big changes in length and force-time patterns (using simple strain gage tranducers) on exposure to trace chemical substances. For instrumentation, preparation and other technique, see (Cook-61) and any current texts on drug bioassay. For

responses to specific low molecular weight substances, for histamine and histidine degradation products see (Mosebach-61), for acetylcholine, see (Cook-61). Greatly exaggerated sensitivities to specific substances approaching a few molecules of very specific stimulus, may be obtained by "pre-sensitizing" the animal from which the tissue is taken with substances of interest using standard immunological procedure. This is classic for bacterial products studies (Schultz-10), more recently (Buckland-60).

In some simple definitive experiments, the antigenic enhancement properties of whole human sebum, or feces and urine extracts, could be examined by attempts to sensitize guinea pigs with these, then measurement of specific and high sensitivities of isolated ileal strips from these animals to such products. This enhancement procedure really could be applied to any of the living tissue biosensing studies discussed in this report.

Electrical events: For bigger flattened pieces of gut kept alive used as membrane barriers, the same rapid electrical signal changes and measurements described for frog skin above, result from applying trace chemical substances. For technique, apparatus, and measurements with specific substances, see (Vaughan-61 63).

Living Blood Vessel and Heart Strips: Strips of a few cm. cut spirally from aorta (a main vessel) of rabbit, supported in simple apparatus, change length rapidly (measurable by strain gage) on exposure to low levels of various chemicals For technique and responses to adrenalin and related substances, see (Furchgott-53) (Helmer-57) (Briggs-61).

Cylindrical pieces of artery or aorta, stoppered at both ends show changes in pressure-volume relations rapidly (by simple electrical manometer measurement) many chemicals (Remington-62).

Whole hearts, removed from frogs and toads in simple support and measurement systems, beat for long periods, show large changes in beat force, size (mechanically measured), when various steroid substances, etc. are applied. For toads, see (Naylor-57); for frogs, (Ware-57, 60).

Living Bladder: Isolated urinary bladder from toad is easily kept alive and set up for pressure-volume change measurement as a function of many different chemically identified trace substances. See (Bentley-58) (Leaf-62).

Living Nerve Tissue: From a few c.c. of brain tissue kept alive from various regions and species, but hard to maintain, self-generated rhythmic electrical signals easily measured change on exposure to chemicals. For human adult cerebellum tissue, see (Cunningham-61).

Handier neural tissue includes nerve and urinary bladder strip isolates from rabbit (Ursillo-61) changing response to electrical nerve stimulation as function of applied chemical substances, and similar preparations of frog sciatic nerve and skeletal muscle. Isolated segments of nerve may be used with down stream propogated electrical signal integrity altered by trace chemicals.

d Bioreceptors Sensitive to Mechanical, Radiant, Electrical Energy, etc.

While chemoreceptors have dominated our consideration of biosensing phenomena plausibly usable for detection of human products in comparison with other methods, the reader should consider the capabilities of several other classes of biosensors, illustrated below, for detection of physical signals and attributes of man, in comparison, again with existing and developmental physical apparatus. These biosensors offer phenomenal sensitivities, signal variable specificities, and in microminiature form can handle some very complex signal signatures (e. g. the few moth acoustic receptors handling the wide range ultrasonic FM bat signal pattern (Roeder-61). These receptors also are self-generating, requiring no electrical power, are extremely small, have out put in pulse form (which can be counted, stored and used in real time computation). The examples only superficially touch on the literature available.

Mechanical Energy Receptors:

Sound: For moth single receptor electrical measurements, and bat signature signals, see (Roeder-61); for bat sensors, see (Griffin-59); for other insect sensors, for isolated spider leg response (VanderKloot-58); and insect ear ultrastructure (Gray-58). For other hair sensilla and tympanic organs, see Prosser, "Comparative Physiology," 1951). For single sensory unit response, cat, see (Rupert-63).

Pressure: For single receptor (Pacinian corpuscle) electrical output data, see (Diamond-58) (Cauna-58), for internal conversion mechanism in these from mechanical to electrical signal, see (Loewenstein-58); for hydraulic pressure receptors (deformation receptors of carotid sinus) see (Landgren-52).

Vibration, touch: cat hind limb vibration receptors (Hunt-61), touch receptor stimulus sensitivities (Catton-62); for touch, skin space-time pattern similarities with hearing cochlear stimulation (VonBekesy-59).

Deformation, strain: Stretch receptor structure and properties compared in seven insect orders (Osborne-62); for isolates from frog muscle, see (Katz-50).

Other: Water flow reception, lobster hair peg organs (Laverack-62).

Radiant Energy Receptors:

Ultraviolet: honeybee ocellus receptors (Goldsmith-58A), their spectral sensitivity (Goldsmith-58B), and electrical output (Goldsmith-60), cockroach ocelli (Goldsmith-58A).

Visible light: From huge volumes of literature, a few illustrations: species comparisons of simple single unit receptors (Wolken-59, 60), other single unit studies (Herman-63). For specific types: squid (Hagiwara-62); crayfish and lobster isolates (Kennedy-61); planaria receptors and electrical responses (Behreus-62); mollusc "neural tissue" photosensitivity (Kennedy-60).

Infrared: chiefly described for viper (Snake) facial pit organ (Block-50); as in rattlesnake (Bullock 52, 56, 57) citing threshold IR energy fluxes at 3×10^{-4} cal. / cm.^{2}/ sec. For most recent work, see (Beichmar-62).

Thermal (Contact Temperature) Receptors:

See analytic studies and reviews of (Hensel-60, 61), major biblio. of (Shambaugh-60).

Electrical Energy Receptors: Not listed with the classical special senses, electroreception was examined early in marine forms, in behavior of catfish to metallic rods in water (Parker-17), and other response studies (Regnait-31). More recently, studies of special electrosensing organs, by (Lissman-50, 51) on Gymnarchus, relations of sensor to low level coded electrical signal emitting organs (Lissman-58A) and to object location (Lissman-58B), to interactions with other animals (Lissman-61). Electroreceptor thresholds stated by (Machin-60) as 30 nanovolts/cm. and 3 nanoamperes current differences, for received electrical pulses of 1 millisecond duration and repetition rates to 300/sec. For more recent reviews, see (Bullock-62) (Lissman-63), for direct recording of electrical output signals from this electroreceptor (amplifier, as it were), see (Hagiwara-62A). Distinguish this communications and obstacle location transmitter-receptor system from high power electric organ action systems-see (Fessard), and many papers of Nachmanson, Grundfest on electric eel in the physiological literature for 20 years. One might expect that structural and functional analogues and potentialities, for electroreception by land forms can be unearthed in the biological literature, but cursory review has turned up only these behavioral responses to electric fields: snail movement patterns changed (Webb-60); planaria responses (Brown-62); activity pattern and oviposition rate changes in flies and other insects (Maw-61); various plant responses (Andres-60). Also studied has been human sensitivity to electrical signals applied to body surfaces in coded space, time and spectral patterns, for communication (discussed elsewhere here). If significant alterations by presence of movements of man were shown to occur in natural electric field patterns of earth and air (described elsewhere here), then pursuit of terrestrial bioelectrosensing, use of marine electrosensing isolates in experiment, would be worth doing.

Magnetic Field Sensitivities:

Mentioned for completeness, a biosensitivity to natural fields, and applied artificial fields, has been claimed based on behavioral observation in lower forms (snails, planaria, protozoa) in a series of studies over many years (Brown-59, 60A, 60B, 62A, B) (Barnwell-61). No discrete sensors have been shown to exist. Again, creation of contrast in environment by concealed human alteration of earth or induced magnetic fields could spur review of known biomagnetic field sensitivities, for comparison with physical methods. For other magnetic field sensitivities, for threshold alteration in frog nerve (Liberman-59); developmental anomalies induced in fruit fly (Mulay-62); for other methods of detecting possible effects, see (Foreman-61), for plant magnetotropisms, (Krylov-60). For other biological effects, see (L. Davis-62B), biomagnetic reviews (Alexander-61, 62).

III Chemical Products Sensing by Chemical and Physical Means

a: General Comments

We seek to observe the individual and collective products of man (see Human Attributes) after passage through environment (see Environmental Modification of Signals) by continuous measurement methods with adequate sensitivity, and specificity, if they are to be useful for detection

Any system must include collecting means for obtaining within a reasonable time a representative sample of air (or water or soil) which might contain human products. Much effort has gone into the consideration of the micrometeorology, sampling statistics, mechanisms by those in the fields of air pollution and public health, nuclear energy, BW and CW (whose techniques are cited elsewhere in this report). (e.g. For methods of airborne material sampling, see U.S. Army Biological Labs-53); Such collection may be done with devices on the ground or in the air (for aerial sampling by helicopter see Gartrell-55, 56A, 56B).

From the large volume of air which generally has to be displaced must be totally extracted its contents of chemical product in vapor, aerosol, particle form, which may then be concentrated into a suitably small volume of liquid or gas for further separation and analysis. Extraction means, may include filtering, impingement, electrostatic precipitation, adhesion, sonic aggregation, sedimentation, thermal precipitation, condensation, etc.

Systems analyses to establish the possibility then feasibility of one or more chemical detection approaches, (considering all variables of source, background, and detection) may be patterned after the methods used by analysts such as the Chemical Operations Research Group at Army Edgewood Arsenal, Md; or with the use of a theoretical model common for both physical and chemical human attributes sensing, along lines suggested under "Physical Signal Sensing", and also carried out by many groups in the physical surveillance field.

The emphasis below will be on physical techniques for chemical analysis, which show the greatest potential for fulfilling these conditions.

Separation Techniques: Whether chemical physical or biological techniques are used for the final analysis of the human product sample, separation of chemical components will probably be required. While the reader should seek data on the various chemical unit operations for separation including ion exchange, dialysis (and other membrane processes), distillation, filtration, etc. illustrative sources are provided below on the techniques of chromatography emerging as important for separation of multicomponent mixtures of macro and micro concentrations of biochemicals, and adaptable for human product separation. Some analysts may go no further in quest for a human products analyzer than a gas or gas-liquid or paper chromatographic system with the various common detector and readout adjuncts available; others would first

consider chromatography as a supporting technique, to be used with the best of other methods described in this report.

Gas chromatography sources include (Pecock-59), (Keulemans-59), (Johns-60), (Janek-60), (Giddings-62), (Symansky-62), (Purnell-62), (Varadi-63). For urine volatiles, se e(Bonnichsen-62), urine aromatic acids (Williams-61), biological amines (Fales-62), for volatile toxics in blood (Curry-62). For special techniques, for dissolved gases in sea water (Swinnerton-61, 62), microanalysis of dihydroxy aromatic acids (Williams-63), micro-system with capillary column and flame ion detector (Halasz-61) and sample pyrolysis as "front end" for gas chromatography (Hayden-63).

For other gas-liquid chromatography, for hydroxy-fatty acid microdetermination, see (Kishimoto-63); fecal neutral sterols (Wells-63) high-speed techniques (Purnell-60) and use with IR spectrometer for fraction analysis (Anderson-61).

For paper chromatography, see review of (Block-58) and for automatic readout devices, see (Parke-52), for other sources, see general reference (R. Scott), amino acid autorecording (Spackman-58) organic acid microgram determination in small samples (Reddle -63),

b. Chemical Procedures

. With limited time available, the review of possibilities for field identification and measurement of human chemical products did not consider at length "wet" chemical analysis. In looking further, the reader should examine the unique features of organic chemical microanalysis techniques related to human chemical products (Edstrom-58), (Morrison-61), (Goldzieher-62), (Henry-63) (Bawden-63) some of which are not yet convertible to physical technique. Also see data on the emerging automatic analysis systems (cited elsewhere in this paper, also see the literature on autoanalyzer of the Technicon Co., papers of Dr. Raymond Jonnard of Prudential Life Insurance Co).

c. Physical Methods

The methods surveyed here have the potential of high speed, sensitivity, substance specificity, wide concentration range, multi-substance handling, adaptation to reliable automatic unattended calibration and analysis. Each data source cited deals with capability for analysis of one or more specific chemical substances known to be excreted by man. Methods vary in degree of separation and purification required for substances in mixtures; as discussed in the papers listed under each method. Chromatography as a separation and preparation technique is the only one discussed herein, but the reader should consult papers of other separation unit operations (e.g. ion exchange, dialysis, filtration, absorption, distillation). One practical solution to multicomponent substance analysis is the composite analyzer, embodying several physical techniques each best in a different class of substances.

This is illustrated by submarine atmosphere and contaminant analysis (Nestler-58), (Piatt-60B) and various people at Naval Research Lab.

1. Radiation Spectroscopy

This offers presently most versatility, and libraries of data on substances properties are available. For organics see (Lang's "Absorption Spectra in UV and Visible Region" Acad. Press. NY 61), electronic spectral data (Ungrade), also see spectroscopy handbook (Clark-60B0, biological materials analysis (Mitteldorf-51) (Penner-59); reflectance spectrometry of opaque materials (Shibuti); and trace analysis by ultramicrospectrophotometry (Craig-53).

Infrared Absorption Spectroscopy: Illustrations are given of available data on substances found in human products. For amino acids, for cystine, asparagine, glutamine to 5 mg. sensitivities, see (Davies-53), also for cystine (Wright-37), and others (Scheidt-52). For purines and pyrimidines, for cytosine to 60 mg. sensitivities, see (Stimson-52), uracil and thymine at low levels (Locker-49). For carbohydrates, see Methods of Biochemical Analysis, Vol. 3. For steroids and other derived lipids, see (Blout-50, 53), (Freeman-53). For high sensitivity to carboxylic acids, see (Mitchell-56) (Pobiner-63).

For measurements of extremely small amounts, for 30 X 10^{-12} gms. of hemoglobin, see (Clark-60A), and for microspectrophotometry through reflecting microscope, see (Barer-59); for review on trace measurement, see (Stewart-59). For other specialized techniques, for compact IR spectrophotometer designed for automatic composition analysis of lunar and planet soils, see (Lyon-63), for IR photometry of CO_2 obtained by pyrolysis of unknown organic compounds, see (VanHall-63).

For IR spectra data collections on substances of interest here, see excellent work of (Sadtler), others of (U.S. Nat. Bur. of Standards), biblio. of IR spectra (Clark-57), gas data (Pierson-56) lipoprotein atlas (Freeman-53). For other discussion on biological materials, see (Andrasina-61); and on complex molecules (Bellamy-58).

Ultraviolet Absorption Spectroscopy: For specific classes of substances of interest such as nitrogen compounds, for amino acids, indoles, uric acids, purines and pyrimidines, see the massive spectral graphs of (Sadtler), and data of (Stimson-52). Also for purines, pyrimidines, and ribonucleic acids, see (Cheng-63). For various other organics, acetone, hippuric acid, also see (Sadtler), (Spector-56). For vitamins and such steroid hormones as estrone, androsterone, see (Loofbourow-43).

Currently, sensitivities in commercial spectrometers are claimed to 10-8 gm. for organics. For microspectrophotometry allowing very low level measurements, for pioneer work, especially on nitrogenous biochemicals (as intracellular constituents in situ) see writings over 20 years of Caspersson at Karolinska Institute in Stockholm, and more recent adaptations, the rapid scanning "cytoanalyzer" UV microspectrophotometer also good for trace substances, made for U.S. Government by Airborne Instruments Laboratory.

Colorimetry: Visible absorption measurements in selected fixed spectral bands are made on compounds of interest to which substances must be added to produce or evoke color. Simple instruments and technique for urine, feces, etc. and extensive tables on procedures and sensitivities for specific substances are prepared by commercial instrument vendors. For automatic colorimetric analysis, see (Skeggs-57); literature on the autoanalyzer by the Technicon Co., and papers of Raymond Jonnard (Prudential Life Insurance Co. in New Jersey). For other procedures data, see (Halvorson-50), (Kruse-53); (Meites-63).

For illustrative data on specific, relevant substances, data for such amino acids as glycine to 0.4 parts per million, isoleucine 3 p.p.m., and a good general discussion, see (Meites-63). See Meites also for such sugars as xylose to 30 p.p. billion, fructose to 5 p.p.m.; also for high sensitivities for arginine (Salake-58), adenine (Davis-63); lactic acid (Tfao-52), ammonia (Kruse-53).

Emission Spectroscopy:

Flame Photometry: Measurements may be made with very high sensitivity, for specific elements from biological products, to parts per billion for some elements (Robinson-61) (Gibson-63). To the frequently measured substances sodium, potassium, also calcium and magnesium handled with simple instruments, are added others observable including Aluminum, Tin, in very low concentrations. For useful data, see Methods of Biochemical Analysis, Vol. 3.

Electrical Discharge: Long used for metallurgical study, technique has special utility for biological measurement. In this, it has very high ultimate sensitivity; nanograms per liter for Aluminum, Tin, Silver, Copper, Manganese, Lead (Cholak-38), and better than part per billion sensitivity for other substances. (Author unknown, for "5 P.P.B. Sensitivity, Anal. Chem. 32: 51A, 1960), also (Methods of Biochemical Analysis, Vol. 3).

Measurements of trace minerals in urine by this technique (Lead, Manganese, Copper, Aluminum, etc.) on comparative ethnic basis (French, Mexicans, Americans, certain Mexican Indians) show significant concentration profile differences directly associated with the soil mineral distribution in the area in which the individual has spent most of his life (Kehoe-40). This could be an important ethnic separation technique ("Man ist was er isst!"). While chief measurements are on mineral elements, for organic vapor emission data, see (McGrath-61B).

Fluorescence Spectroscopy: Excitation of substances of interest by UV yields reemitted radiation for analysis of longer wave length. Substances may fluoresce directly or require chemical treatment to produce this.

Illustrating specific fluorescences of interest and extreme sensitivities, uric acid at 0.7 p.p.m. (Duggan-57), guanine at 0.1 p.p.m. (Long-61), aromatic aldehydes and acetals (Crowell-63), arginine (Conn-59). For more data on specific compounds, see (Long - Biochemist's Handbook-61), for method, see (Udenfriend-62), (Meites-63). Claims of ultimate sensitivities to 10^{-13} gm. have been made.

X-ray Spectroscopy: Ammonia and various nitrogen-containing biochemicals can be determined in submicrogram quantities (Mathies-62) who has extensively surveyed use of this technique in biology.

Raman Spectroscopy: Certain samples excited with bright narrow-band visible light re-emit weak bands on slightly different wavelengths. Effect is based on special vibration-rotation properties similar to those involved in IR molecular absorption, except that one can use visible spectral observation. Previous

limited use (because its source brightness, spectral purification, detector sensitivities were not good enough), now will change with availability of very bright narrow band laser sources, ultrasensitive and synchronous detectors, etc. (see July, 1963 Scientific American for illustration of very new laser Raman spectroscopy).

For measurements on specific substances of interest on human detection, for amino acids, cystine, alanine, histidine at low levels, see (Edsall-50); for others (Nicholson-60), (Ewing-60). For related new instruments and methods, see (Mangini and others in "Advances in Molecular Spectroscopy").

Mass Spectroscopy: This technique of analysis and identification of elements and compounds by their mass offers great sensitivity and selectivity. For some, early stationery magnetic instruments can be replaced with miniaturized RF-electric field mass analyzers good enough for satellite work. Early use for element analysis, is now extended into observation of certain organic compounds, but limited to study of structure and bonding in these compounds, since each substance put in for analysis generates a very complex "fingerprint spectrum" empirically identified with the substance, with the specific instrument and its conditions of use. A mixture of organic unknowns is almost impossible to resolve and identify at the present time, but if pre-separation and purification as by gas chromatography is applied, phenomenal sensitivities are possible.

For specific substances of interest studied: for element lines catalog (Owens-62); a variety of organics (McLafferty-63); steroids (Fitches-63). For food volatiles directly analyzed (Bazinet-60) or measured after gas chromatographic separation, see (Merritt-58, 59, 61).

For other uses: for complex ions, see (Heath-62); dissolved sea substances (Benson-61); rapid reaction studies (Goldfinger-63). Good general recent references include (Ellicott-63), (Udenfriend-62), (Masica-60), (Ewald-53).

Magnetic Resonance Spectroscopy:

Electron Spin Resonance (ESR): Some interesting possibilities for detection assert themselves here. Free radicals and reaction intermediates, paramagnetic substances such as oxygen, other substances with unpaired orbital electron spin properties can be observed to phenomenally low levels, e.g. to 10^{13} free radicals (Commoner-58), (Crouthamel-61A) with hope of extension to 10^{9} free radicals.

Amino acids, polypeptides and proteins, exhibit free radical content measurable by this technique, after their irradiation with ultraviolet (Gill-62). In other experiments of (Norins-62) a dermatologist, human skin, irradiated with 250 MU UV, shows free radical production measured by ESR apparatus (with sample in a magnetic field, and illuminated with 9500 mc. electromagnetic radiation). The work was limited to isolated material, and extended observations made by low temperature thermostatting. Both Gill and Norins' work should be extended to experiments in UV irradiation of intact skin on a man (arm, hand, etc.), at normal skin temperatures, then observing free radical production in suitably designed ESR apparatus.

Further, it would be reasonable to carry out a short theoretical study, of remote ESR observations of free radical production at skin surface, of man (at various assumed and arbitrary free radical production levels) assessing levels of excitation UV needed, and analytic illumination prospects (required magnetic and RF fields).

Other activated intermediates are observed by ESR in enzyme controlled reactions (Chance-59). Observations of such intermediates in nerve (Blois-61) have encouraged preliminary work of (Kelly-63) (at Brooklyn Polytech. Inst. for Air Force office of Scientific Research) to attempt to observe remotely by ESR (without contact electrodes on tissue) neural activity, including signal traffic. His theoretical construct revolves around assumptions derived from work of Nachmansohn, etc. an acetylcholine free-to-bound form changes associated with nerve fiber membrane alterations with signal traffic. At the time of his last available report, apparatus had not yet been completed for remote observation or experimental validations been obtained, even on isolated peripheral nerve segments. If observations of this type show significant signals due to neural activity, these should be extended to near proximity whole animal and human measurements, and tied to the theoretical analysis of far remote ESR viewing suggested above for skin.

Nuclear Magnetic Resonance: This technique revolves around nuclear (rather than orbital electron) interactions with applied magnetic and electromagnetic radiation fields.

For direct observation and data on specific substances of interest; for quantitative organic measurement, see (Williams-58), saturated and unsaturated fatty acids and protons in any materials (Jardetsky-62), phosphorus (Callis-50). For specific hydrocarbon (petroleum fraction) analyses, see (Williams-59B). For general references, see (Muller-56), on biological applications, see (Jardetsky-62).

Electrochemical Techniques.

For continuous measurement of certain substances produced by humans, various electrode probe sensors can offer high sensitivity, specificity, and good response time. For Na and K (glass)electrodes, see (Friedman-59, 61); and descriptions of good commercial instruments(illustrated by Beckman Co. data, also available from them for O_2, CO_2 and pH electrodes). For Ca electrode, see(Ishizawa-62). For other polarographic electrodes usable for various gases, see(Dehn-62). For discussions on polarographic measurement at very low concentrations of a wide variety of substances in solution, see recent editions of definitive review books by Heyrovsky, Lingane.

Anodic stripping techniques offer nanogram sensitivities for certain substances(Birks-60), for use with the trace components of Dead Sea brine, as example, see(Ariel-63).

Other electrodeposition techniques have extreme sensitivity and specificity for certain elements of interest(Weissenberger-60), down to micromicrograms in some measurements(Stolyarov-54).

Other Techniques.

Trace measurements of multiple components in biological material by radioactivity activation analysis is described by (Tobias-62), for heavier elements(Harrison-55) and in various places by (Udenfriend). Sensitivities of better than 10^{-15} gm. are attainable with adequate scintillation detectors. See (Crouthamel-61B) and other references in sections on Radioactivity in this report.

For extremely high sensitivity measurements, below 10^{-12} gm. which may be necessary for some human emitted components of interest, while no documentation is provided here, the reader should look for recent papers on nucleation techniques(eg. using halide photoemulsions, Nieset films studied by Army Chemical Corps, evaporated thin film semiconductor detectors); also the phenomenon of "fluorescence quenching".

IV. Physical Signal Sensing.

a. General Comments.

Discussion in the next few pages of specific sensing techniques and sources of information, should be related to the information in sections elsewhere on physical signal properties of man, and their environmental modification. A brief discussion follows those techniques, on systems considerations in sensing. Adequate source material is believed to be available to the reader here, to carry out system analyses of several alternate systems embodying different physical phenomena, and to construct a common model describing their behavior.

b. Radiation Sensing.

Radio and Microwave Sensing.

Heat production by man results in radiant energy emission chiefly in infrared, but also in a "tail" at low levels well into the microwave. Sensitive radiometers can observe this emission relative to surround. (See Hooper). "Calculation of target temperatures in Microwave Radiometry" Naval Ord. Lab, Corona, Cal., and microwave radiometer surveys for terrain mapping (Porter-60). For radiometers see (Copeland-61), X-band phototube (Douglas Air-63) millimeter masers (Walling-62). Other microwave (thermal radiation) measurements (Dicke-46), and general sensing biblio. (Harvest-56). For auxiliary techniques, for millimeter spectroscopy on various substances (Gallagher-62), microwave spectroscopy (Strandberg), microwave absorption measurements (Salaty-59), and "active" observations are to be considered if target is to be illuminated, see (e.g. work on coherent generation of radiation in the millimeter and submillimeter range (Hakki-61) and 100 KW 3 mm. radiation sources (Sedin-62).

Infrared Sensing.

For detector data, see (Gelinas-59), passive techniques (Barnes Eng.-59), survey of (Kennedy-60) (Levinstein-62), (Kruse-63), (Wrobel-63), for uncooled 10U detectors (Drennan-63). For recent unclassified reviews of IR-visible image converters, see (Woodhead-62) also one able to view man at 150 yards on moonless night with 45 lines/mm. resolution (Franks-62).

For supporting information on IR spectrophotometers, on accuracy (Stewart-60), 2-16U calibration substances (Plyler-60), or air borne units, see (Brumfield-60); for far IR units (Bohn-53); for filter separation up to 16U see (Billian-63). Other data, on mineral identification and measurement, see (Tuddenheim-60); IR instruments measurement, and environment problems on Atlantic missile range (Marquis-61), pulsed modulation IR systems (Wilson-60), extremely high power coherent sources, if human subjects will require illumination (Baird-62).

For basic IR references, see (Hackforth-60), (Kruse-62), review of analytic techniques (Bentley-57); military applications (Ballard-56), see also infrared Symposia (IRIS) classified reports in ASTIA.

Visible Light Sensing.

Much data are available in the current commercial literature on a wide range of photosensors (emissive, conductive, em.f. producing), image forming pickup tubes, spectrophotometers adaptable for field measurements of properties covered in this report.

If active illumination techniques are to be considered, for reflectance analysis, movement detection, behavior disturbance induction, range finding, the following open literature sources on lasers may be of value: laser range finders (Karr-63), detection of movement by Dopplermeans (Emerling-61), several physical property reviews (Birnbaum-62) (Blattner-63) and (Sirons-62) who provides a thorough systems analysis for sources, transmission medium, receiver target, etc.

Ultraviolet Sensing.

For detectors, 50-1500A review, see (Weissler-62), for good survey of "solar blind" detectors sensitive under 3000A, see Dunkelman's papers in 1963 NASA Report Series.

For supporting concepts, on UV-transmitting fluids for ultra-rapid shutters (Kerr electro-optic) see (Harris-62); interference filters (Klementyevs-60); 2000-3000A solar spectrum simulation (Norman-63), new UV laser (continuous wave, with piezo electric interference modulator) (Sylvania) perhaps usable in stimulation of free radical production in man (discussed elsewhere in this report).

For other data: military considerations on detector reflectance, scattering, calibration, see (LeBlanc-62); other middle UV applications (Green-62).

X-ray Sensing.

If unique human contrast properties are to be observed, at useful ranges with respect to air transmission, source data here may be helpful in analysis and detector selection: for image forming devices, x-ray camera tube (Rutherford-62), x-ray to visible light converter (Tunge-59). See also commercial descriptions of the range of fluoroscopic image intensifiers available.

Energy sensitive detectors, will be needed to separate sharp signals deriving from human bone Ca-P or other human characteristic return from noise background. See those used by (Porges-58) and (Gravitt-62) at ERDL.

Other Radiation Sensing Information.

For specific sensing studies for terrestrial (Drummond-61) radiometry for unenclosed object temperature (Emslie-60); photodetection parameters study (Merriam-62); spectroradiometry (Marchgrabers-59); remote sensing of environment, symposium (Institute Sci. Tech., U. Mich.). See, of course, also the annual lists of publications from Project Michigan on radiation surveillance detectors.

For good systems surveys over broad spectral ranges, of spectral suitability for communications, surveillance, (and discussion of all component measurements) for 30-10,000A see (Bayley-62) for UV to submillimeter, see (Chapman-61).

For other related data: reflectance spectrometry of opaque biological materials for chemical (composition) analysis (Shibati); from electromagnetic pulse sources and detection biblio. (Blank-63), electromagnetic hazards

(Triggering) of ordnance (Gallios-62), electro-optic and magneto-optic phenomena (Rung-59).

c. Sound and Vibration.

Airborne Sound.

In considering active illumination and sensing analysis, see "Human Attributes and Contrasts, Physical" for reflectance and other factors.

For sensing in active or passive systems (of human activity, etc.) in ultrasonic regions, see (Kamm-62), ultrasonic physics (Richardson-62), also L. Bergmann "Ultrasonics" in English translation. For measurements in various regions, see (Beranek), and related physical acoustics data (LuKasik-55), (Bolt-52) and Olsen at R. C. A. on "Acoustical Engineering".

For observation of behavioral changes induced by sound (not observable by sonic techniques), see "Stress and Induction of Behavioral Responses."

Seismic:

For passive observation, see seismic measurement data of (Bartunek-55), (U. S. A. F. Technical Applications Center and VELA-61), for seismic data processing (Phinney-62) and Soviet seismometry review (U. S. Lib. Congr. -61). In active observation, excitation of earth may be done by the explosive techniques of geophysical exploration, or, specific surface patterns induced by continuous excitation of vibration generator (aircraft "shaker" dynamic structural analyzer) and return anomalies due to human presence sought.

d. Other Physical Sensing.

Radioactivity:

See discussion under Human Physical attributes, Radioactivity, for active illumination sensing and passive sensing techniques, including those of special capability used for aircraft landing glide path aids.

For other references in this field copiously represented in the military measurement literature for sensors, see new nuclear radiation guide (U. S. A. F. Aerospace Med. Lab. -62) dosimetry field review (Taimuty-62), methods for assaying human radioactivity (Onstead-60) neutron radiography (Schultz-61) and neutron spectrometer (Friedland-62); reactor effluent analysis (Melgard-62).

Electric and Magnetic Field Sensing.

See discussion under Environmental Modifications, "Physical Signals" concerning measurement techniques.

"Non-Destructive Testing"

A variety of laboratory methods involve non-contact or remote observation and inferences about specific physical properties of materials (e. g. optical, mechanical, thermal electrical). These are chiefly extensions of techniques discussed elsewhere in this report, but can tell much about surface, internal structure, composition, loading, etc. Detailed analysis of some of these successful methods could suggest other physical and chemical attributes and properties of humans to be viewed remotely and perhaps other remote information-conveying methods. For general references, see handbook (McMaster-59), biblio (Briggs-62) surface motion measurement by proximal

instrumentation (Pierce-62B). For optical methods, see (Heavens-61) and photography for surface motion (Hefferman-62). For electrostatic observation of mechanical changes (movement and acceleration, pressure), see (Brookes-Smith-39). For radiography, see (Schultz). Microwave reflectance can yield quantitative evaluation of dielectric constant and conductivity of surfaces (Hochschild-63).

By sonic methods, some in ultrasonic ranges from 0.2-100 mc/s., spectroscopic techniques and return pulse contour analysis (Gericke-60, 62) and co-workers at Watertown Arsenal look for internal discontinuities and flaws in objects "illuminated;" residual stress is measured by sonic scattering (Rollins-62), and surface hardness, ultimate strength other properties may be examined. See (Morgan-63) for ultrasonic testing techniques for diverse materials. For precise analysis many methods require that transmitter-receiver be coupled to object through liquid medium, but limited analytic measurements for materials properties can be made through an air (atmospheric) link.

e. Physical Systems Considerations.

No attempt has been made to construct a human detection analytic model in this preliminary study. Further analysis will require identification and inventory of operating parameters for each of the major components of the system. A few are illustrated below:

Human target variables to be further defined can include geometric projected area, active emission and/or scattering (and reflection) coefficients and cross sections, emissivities; their spectral, geometric (e.g. angular), time dependence; polarization, energy transformation functions (fluorescence, radioactivation, etc.); for skin and also for selected clothing, metallic and conducting objects, other companion artefacts.

Environment parameters include: background-source variables (emissions, reflections of animals, plants, terrain, atmosphere) with the same factors and dependencies for human target. Other environment signal transmission parameters describe air transfer function and spectral dependence (highlighting bandpass regions), and ground transmission for seismic, electrical, magnetic signals; variations with weather (RH, temperature), time. Transmission factors must be considered for 2 way path if active illumination of subject is used; return signal transmission may be different (due to fluorescence, radioactivation, non-linearities of air for high intensity sound, etc.).

For receiver variables, consider aggregate "black box" of sensor, amplifier, signal conditioner (calibrator, wave shape, correlator, etc.) indicator device. Variables include sensitivity, amplitude range time-based band width, radiation spectral band width, spectral resolution and spectral scan pattern, optical acceptance angle, image resolution environment scan and track variables.

If observer uses active illuminant source, variables can include: total intensity, spectral distribution, degree of coherence, modulation wave form, beam angular dispersion, ratio of target to background illumination.

System variables to be derived include contrast ratios (selected human signal variables versus corresponding environment background level); energy product-integral (integrated for selected bandpass regions) taking into account (source spectral emission, target and background spectral emission and reflection, air, etc. spectral transmission receiver spectral sensitivity). Of interest are total sensitivity, working range, human contrast ratios for positive identification, angular resolution.

These are all but a preliminary and primitive point of departure for construction of a theoretical model for predicting the comparable effectiveness of various physical phenomena in human detection, and could be made broad enough to permit study of chemical variables and chemical detection systems. Military and civilian surveillance system analysts have a great number of satisfactory systems models for such analyses; they await only good information on new aspects of human emissions and contrasts.

F. OTHER RELATED INFORMATION

I. Stress and induction of Behavioral Response

In concealed enemy "illumination" by physical, chemical, biological or psychological means, may induce additional behavioral and neural responses useful for detection. Such responses may be obligatory, unavoidable, physiological, or related to the induction in enemy mind of real or fancied threat to mission and life.

Return signals from such behavioral and neural response may take the form of various direct emissions (ex: EEG changes), body movement and activity responses, or indirectly contribute by placing the enemy into a more exposed position for detection, or by alteration of his course of action, or temporary or permanent neutralization of rational behavior, remove him as a threat.

In brief form we consider specific stresses and performance changes, light, sound, movement restriction, sleep deprivation, CW alteration, other physical and chemical stimuli having psychological impact. Many initial physiological degradations discussed are but way-stops towards reduced psychological performance capability.

Light Stress. Flickering light was investigated by many as a means for degradation induction; for broad coverage of human responses, see the ERDL Flicker Symposium(Bach-57). For detail on various central nervous effects, see (Walter -49) more recently (Brazier-2 refs) including EEG changes and generation of illusion and hallucination. For other mechanisms, topographic mapping of regional brain responses see (Ulett-58). Repetitive light, also called "photic" stimulation, is used diagnostically at low light pulse repetition rates(under 15/sec) to evoke seizure activity or EEG changes in latent epileptics or those with CNS lesions. EEG response events in normals have a certain synchrony with the repetitive light stimulus, and if human neural activity could become observable by non-contact methods, remotely(discussed elsewhere in this report), a photo-stimulation-synchronous detection system might be considered for man.

In normal people at low repetition rate of pulsed light stimulation sensation is of separate light pulses up to a point of continuous light sensation (CFF at critical flicker fusion frequency). For extensive data on this, see bibliography of (Landis-53), studies of (Bartley- 37, 39, 51) prolonged stimulation effects (Alexander-59); alteration of CFF with simultaneous patterned sound stimulation (Kravkov-35A, 35B) (Knox-45A, B) (Maier-61) (Ogilvie-56). If paired flickering sources operating at different frequencies are used simultaneously, an additional sensation of visual beats (at difference frequency) is produced. (Attneave-50). These various effects described by authors above can be produced even when eyelids are closed, if source is bright enough, and for certain desired effects(behavioral alteration, neural signal return) repetitive pulsed laser beams may be considered for this purpose, with exploration yet needed of effects of stimulus pattern and waveform, other than simple repeated pulses.

Personal protectors, goggles, mask, countering this would have to be applied in advance, would obscure the use of vision for other tasks at the time, and would be an extra equipment burden not likely to be carried by enemy forces, except under total threat conditions.

Direct electrical stimulation of the head and of the eye can induce visual sensation (Bogoslowsky-37,47A,47B) (Bowman-35-51). No documentation has been seen of such induction by remote electromagnetic radiative or electric field action.

Another light stress involves use of a bright unexpected flash source, producing temporary incapacitation, perhaps during important viewing periods, or persisting to destroy night vision or permanent blindness.

Related Visual Capabilities Information:

Degradation must be consideredin relation to standards of performance, for a given operational task. The following will provide useful sources on operational needs for vision in reconnaissance, search and detection recognition. For detectability in visual search , target factors, see (Kulp-59); and contrast as a function of illuminant spectrum, see (Nagel-56); for dark adaptation responses bibliography (Crook-53); for continuous search problems, (Delse-53) (Ericksen-54). For form discrimination (Fox-57) and its determinants (Bitterman-53) for other pattern recognition concepts see (Weisz-58), and in relation to target geometry (Steedman-60). For other visual capability in the action enviroment , see (Blackwell-57A,57B), and in special problems of military aviation (Wulfeck-58). Visual presentation of information (Baker-54) and visual interpretation of photographs and fixed electronic images, see (Waldron-61) (Gwier-56) (Shenkle-56).

Sound and Noise Stress

Noise is observed to have many effects on human behavior. (Corso-50-52), (Anthony-57)(Azrin-58), for animals (Ades-53)(Ackerman-53). (Hale-53); for biological changes. Sensory changes include altered visual performance (Broadbent-54) (Loeb-54); including altered visual signal detection (Watkins-63). Noise also can produce body movement changes (Krauskopf-55), and muscle tremor (Loeb-54).

Intermittent noise has special effects, somewhat similar to flickering light. At low interruption rates it is perceived as separate pulses (flutter), fusing into continuous sound sensation at higher rates (Allen-24) (Ogilvie-56) (Gebhard-59). Interrupted sound degrades a variety of mental capabilities (Ogilvie-56) (Gebhard-59), also inducing confusion, inattention (Mowbray-56). For other CNS effects see (Smith-50), and for EEG responses and changes, see (Mimura-62).

Speech communication (production and reception) can be systematically altered. For speech jamming, see bibliography (Moyer-55),(Christman-57B) (Licklider-57), and (Stewart-58). Stewart also discusses antijamming procedures.

Sound and noise sensation, and disturbances due to them, can be induced in man with RF energy directly beamed at the head. See (Frey- 61A,61B,62),

using fairly low energies, a variety of frequencies and modulation patterns. (This might be classified as Radiation Stress, RF Reception, etc).

High intensity audio or ultrasonic airborne sound has distinctive effects on living material, close to the sound source, unfortunately not observable afar (more than a few feet) because of the limited properties of air to conduct this energy (non linearities at higher amplitudes).

High intensity vibration. Special effects on man, surveyed by (Edwards-50) (Coermann-60) (Goldman-52, 61).

Related Hearing Capability Information

For normal performance capability data, for noise detection, see (Green-60A) sound localization (Snow-54) (United Research-62); accuracy in gun fire localization (U.S. Army ORO-58); and localization capability with conflicting hearing and visual cues (Witkin-52). For hearing vs. vision, for communications see (Cheatham-50), (Day-50), (Henneman-54).

Other Stressors

For temperature effects, for low temperature, see (Carlson-54)(Rodahl-57A) human temperature limits, (Wing-63), (Fenning-54). Heat regulatory responses (Newburgh-59).

For sleep deprivation effects (100 hrs.), see (Edwards-41), psychological changes (Murray-58), other impaired performance (Williams -59). For work-rest schedule change effects (Ray-60), (Chiles-61). For altered daily patterns and performance effects (Brindley-54).

For restriction of movement and confinement, effects on exploratory behavior (Montgomery-53), perceptual function changes, see (Ormiston-61), and responses of captives (Biderman-61A, 61B). For sensory deprivation and behavior see (Wheaton-59), (Leiderman-61) and effect in visual processes (Heron-56) for sensory isolation and confinement biblio. see (Weybrew-60).

Many drug agents offer possibilities of incapacitating potential (see any good recent pharmacology compendium such as Goodman and Gilman). With these and newer psychopharmacological materials (see "Psychopharmacology" published by U.S. National Research Council) there are manifold possibilities for promoting detection by physiological alteration and CNS sharp edged "chemical dissection" for behavior distortion, not to be catalogued here. Documentation of specific potential agents, and supporting techniques and possible modes of use having tactical worth related to the detection problem are kinds of information best sought from such sources as the restricted accessions lists and card catalog of holdings of the Army Chemical Laboratory at Edgewood, Md., Army Biological Laboratory at Detrick Md., etc.

For other drugs affecting performance see one biblio. (Trumbull-58).

For thirst data see (Wolf-58).

Microwave Stressor Effects: Functional disablement and death without pathology is reported, for Rhesus monkeys, by Dr. P. Bailey of NIH = National Institute for Neurological Diseases and Blindness; with similar results reported, using 300 mc. carrier, 500-1000 cycle sine modulation (see Bach, p. 82 U.S.A.F. 3rd Annual Triservice Conf. on Microwave Hazards). For sleep induction by pulsed RF see (Burhan-59). Visual system damage includes lens opacity and tissue degeneration, for 3 cm. data, see (Buchanan-61) (Susskind-51); at 10 cm. (Carpenter 59, 62). For other CNS degradations see conditioned response experiments of (Jaski-61) . For induction of hearing sensation see (Frey-61A, B, 62). For skin damage see (Novaro-50). For other hazards see reviews (Turner-62)(Schwan-56A, 59) (Hines-52) (Jaski-61); for pathological and physiological changes (Herrick); for effects on isolated tissues (Schwan-57B) and on specific organs (Myrtenko-62A) other local effects (Myrtenko-62B).

Responses to Applied Electric Fields: Electric signals can induce visual sensation (with electrodes applied to head). Fairly low power is involved see (Schwarz-38) for quantitative data re stimulus quality, adaptation (Schwarz-40A, 40B, 47) (Motokawa-49, 50A), certain resonance effects (Motokawa-50B), selective color stimulation (Motokawa-52), . For the specific eye and CNS structure responsible for electrosensitivity, see (Brindley-55) and for sensation induced in dioptrically blind (retina intact but cornea, lens opaque) see (Barnard-47).

Electrostimulation techniques for hearing are being investigated by (Intelectron-63). Electrical sensitivities of skin presently are only exploited in communications studies with all variables of voltage, current, waveforms and spatial patterns available from this. See (Anderson-51), (Hawkes-59A, 59B), (Foulke-62). No direct attempts have been made to use remote electrical methods for inducing some of the bizarre sensations or hallucinatory responses relative to the common special senses described above. Direct or remote electrostimulation as a stressor has the potential of inducing a variety of degradation responses. (See wide range of papers and monographs on Electro Shock in the psychiatric literature). But some of the effects set down are interesting enough to explore the parameters and mechanisms for remote induction of behavioral response by electrical means.

Other Comments on Psychological Stressors: A good starting point for review of disabling techniques can consider the inverse of those factors found to promote survival and stable behavior in disaster situations, as those below, modified from (Smith and Cox-57) studying reduction of human stress after irradiation, and (Torrance-53) on survival psychology: many specific physical or chemical stressors can be used to induce one or more of these actions: impose new situationes , unfamiliar to enemy , and designed to make certain of his training worthless; keep him as ignorant of his true situation inducing his disorientation if possible; (see Withey-56 - reaction to uncertain threat). Induce fear, panic, anxiety, insecurity as to his future situation. For source references: on anxiety,

initiation , its communication and interpersonal management (Ruesch-49), anxiety induction and intellectual function (Beier-51); fear-arousing communications (Janis-53), anxiety and hysteria dynamics (Eysenk-57); deception detection (Ellson); seek to reduce his belief in his own effectiveness and his resolve and determination, induce personal conflict, reduce confidence in his leadership; seek to modify his action, either immobilizing him, or forcing hasty action.

Magnetic Field Stressor Actions: No definitive data on human degradations in exposure to strong magnetic fields was seen in the literature although preliminary explorations by (Beischer 62A,B) in such exposures have begun.

For induced visual sensation see (Swinton-11)for quantitative analysis strength-duration data, typically at 900 gauss, 60 cycles (Barlow-47).

For other speculations on human responses to magnetic field stresses see (Hansen-48A), who postulates the autonomic nervous system as the mediator of such effects (Hansen-49), other vague physiological effects statements (Thompson-10) (Fleishman-22).

Other Behavioral Responses to Stress: Vigilance can be defined as attention to a task involving important infrequent events. (e.g. for anti-submarine warfare biblio.-see McGrath-61A). For vigilance reduction, see (Frazer-52) (Wade-61) and for general neglect of attention to changes in surroundings, see (Berlyne-51).

For fatigue sensation and performance impairment, behavioral and physiological changes, see biblio. (Bevan-57) for measurement (Motakawa-48) and induction, see (Bowan-52), for skilled performance degradation, see (Bartlett-41), and biblio. (U.S. Joint Service Steering Committee for Human Eng'g..), for other effects, see (Univ. of Md. Psychol. Dept-52),

Various odd behavioral responses, biblios. of military psychiatry (Roos-59, 63); ecology of psychiatry (Meerloo-59).

Other Changes in Response to Stress: For general reviews see(Grinker -45) (Lazarus-52) (Harris-56) symposia (Tyhurst-50) and others (Klier-60) (Renbourn-61), biblio. (USASTIA-Bib.-62) (U.S. Army Med. Service Grad. School-53) physiological and behavioral measures (Notterman-55), biblio. on development of stress-sensitive tests (Iller-53) decrement in aircraft stress (Finan-49)c basic performance capacity study (Spector-61), desert survival responses (Howard-53).

Heart rate in anxiety (Dean -58) and CV changes related to religious practice (King-57); conditioned heart rate response, control (Bersh-57).

Skin secretory changes under emotional stress have been classically studied (C.Darrow-34) also by (Conklin-51)(Johnson-59) by measurements of skin resistance and other electrical changes (e.g. GSR or galvanic skin response). Such changes will affect the pattern of released chemical substances, also in changes of surface conductivity, skin blood distribution etc. may be observable as electromagnetic radiation emission or reflection changes.

II Some Other Human Spotting or Remote Data Transmission Problems

Casualty Location:

Even when individuals are equipped with small beacon transmitters, and are deployed around the terrain in stationary semi-concealed positions, simulating casualties, it is difficult to find them: (See records of survival location experiments conducted by Stanford Research Institute at Army Combat Development Experiment Center in Calif., with average locating time 1/2 hour (U.S.-CDEC-61). Urgent desire of Army Surgeon General's Office to locate personnel (casualties) quickly because of hemorrhage etc. despite difficulties of security, enemy decoys, radio propagation, has promoted studies chiefly of manually and autotriggered active emitters (radios) carried by all, (eg. 265 mc., a few milliwatts, 500 yard range). While we cannot hope to put active emitters on enemy ("bell the cat"), broader surveys of various active and passive information links for casualty location have been undertaken; this information and the experimental procedures used in deploying concealed casualties under realistic tactical conditiones, can be of value in conducting concealed personnel detection experiments or studying alternate locating techniques. See also (Jackson-62) and from Air Force Study on survivor locating devices, see (Matrix Corp-61).

Physiological Performance Telemetering:

To assess human biological and psychological changes at tasks in remote or enclosed environments (aircraft, satellite, undersea, land vehicle, chamber), varieties of transducers applied to the body measure biopotentials (EKG, EEG, ERG), blood pressure, respiration, temperature newer variables; electrical signals produced modulated RF or inductive transmitters mounted on the person or wired within the environment, and remote decoding of signal is done in "real time." Only little encouragement is available for remote sensing of any of these variables, of characteristic patterns denoting human life without the transduction of each variable into a modulated RF signal. Exception would be skin temperature (and associated IR emission), perhaps other passive (reflectance and scattering) responses to electromagnetic radiation, particles cited elsewhere in this report. But the basic internal human signals, (e.g. of EKG, respiration, heat production) exist in roughly invariant pattern as long as life persists in the man and represent an interesting but presently elusive "handle" to get at for remote detection.

Animal Tracking:

Similar data on physiological conditions, and on movements are collected in recent animal studies; for radios on grizzly bears, see (Craighead) other wild animals (Lord), woodchucks (Merriam). There are similar studies on birds especially related to navigation, for fish homing (Hasler and Henderson), on monitoring of locomotor and electrophysiologcal activity, see (Dutky and Schechter of Dept. of Agriculture). In future human detection experiments, transmitters placed on some of the large members of the animal population in the selected area, will provide location correlates for other physical and chemical interferences with the human location principle under study.

III. BW-CW Detection Problem Similarities.

Aid in analysis and solution of the human detection problem can certainly be derived from the past and present efforts on BW and CW detection with which many points of correspondence exist. Air sampling, collection and concentrating its contents into a convenient volume for chemical, physical or biological analytic instrument, must take into account the same kinds of micrometeorological (e. g. temperature and movement gradients, turbulence) mechanical (devices) statistical (space and time sampling) and chemical problems, whether for remote observation of human chemical product, or trace amount of chemical toxic or biological pathogen. Additional similarities exist in distinguishing the agent (or human product) from background substances from animals, plants, industrial wastes, etc. , and in the selection of specific and known compounds in the tissue or products of microorganisms unique to those organisms (e. g. amino sugars, D-amino acids, diamino pi melic acid, etc.) (see Wolochow-59).

For good speculative early surveys of a wide variety of techniques for BW detection, see (Bateman-51) and more definitive reviews of many possible physical and chemical principles for BW detection by a National Research Council Advisory Committee, see (Bolduan).

For a few examples of some common instrumental approaches, see partichrome viable-particle stain and size distribution analyses (Nyman-62); protein analysis in air, at 10^{-9} g/l (Buban-62); determination of microorganism IR spectra (O'Connor-Dept. of Agriculture-55); determination in atmospheric paths of IR absorption by certain CW agents (LOPAIR technique); for a variety of early protein and bacterial methods (fluorescence, serologic, dyes, see (Armour Research Foundation-54); for more recent biochemical detection methods, using bacterial enzymes and fluorescent techniques. See (Mitz-62) and for exploration of chemical concentration profile procedures, see (Melpar-61). For general review of use of living materials as transducers for BW detection, see (Kornfield-62A, B, C, 63).

To get current information, consult the work in progress on new techniques by two major BW Detection System Study Contractors (Melpar-Falls Church, and Aerojet General, in California), in behalf of Ft. Detrick, Physical Defense Division; the corresponding CW Detection efforts monitored at the Army Chemical Laboratory and CBR Agency at Edgewood, the reports disseminated through DDC (formerly ASTIA) "Field of Interest Sections 3 and 3A", and the Technical Document Library resources at Army Chemical Lab and Army Biological Lab.

IV. Other Useful Information Sources.

In the course of our review, the following sources were examined, and may be useful to a reader going further in study of areas described in the report. These are not cited elsewhere in the report.

Biology: For distribution and abundance of animals, and ecology, see (Andrewartha-54), (Clarke-54), (Clements-39) (Kendeigh-61) (Alee-49) (Odum-59), including a glossary (Carpenter-56) and animal geography (Hesse-51), (Darlington-57) (Hubbs-58) (U. S. A. F. Arctic Aeromedical Lab Publications-1962). For wild animal studies under controlled conditions see (Calhoun-56), for animal attractions and repulsions (Coleridge-20), animal orientation (Fraenkel-40); for ecology of parasites, see (Baer-51) and for host specificity (Becker-35). For insect physiology, see (Wigglesworth-53), on bumblebees (Free-59), yellow fever mosquito (Christopher-60), and other mosquitoes (Bates-49), spiders (Bristowe-58), ticks (Arthur-62), and insect control biblio (Horrigan-51). For mammals, see field guide (Burt-47), also (Anthony-28) (Hamilton-59), mammal bioclimatology (Pruitt-56), and tropical and arctic mammal and bird heat (Scholander-50). For falcons studies as pets and hunting animals, see (Russell-40) (Momin-45) (Wood-55).

Chemical Analysis: For amino acid separation, see (Hamilton-59); for amino acid automatic analysis (Piez-60); and for amino acid handbook (Block-56). For ammonia determination, see (Connerty-57) (Henry-58) and for on detection and differentiation of glucose and amines, see (Williamson-63). For lipid biochemistry see (Devel-55), and for all the properties of water in early work, see (Dorsey-40). For general biochemical reference, see (Merck Index-60), normal clinical lab data (Mattice), big compendium on methods (Gradwohl), other standard methods (Welcher-63), industrial toxicological chemistry (Elkins-59), drug detoxication mechanisms (Williams-59A); for insect biochemistry, see (Gilmour-60).

Perfume Chemistry: related to identification by scent producing animals, chemical composition of scents, chemoreceptors and biosensing (discussed elsewhere). General references (Askinson-24) (Hoffman-48) (Pounder) (Jellinek-54) good work of (Givaudan-49); (Moncrieff-49); (Verrill-40), others on animal perfumes (Sagarin-44), (Lederer-46), musk odorant composition (Pogert-20) (Ruzieka-26), natural and synthetic musks (Dyson-31); mercaptans in cosmetics (McDonough-47); also on cosmetic materials (Keither-56) (Sagarin-57), handbooks (Greenberg-54) (Denavarre-57); and for flavors and essences (Gazan-36).

Physiology and Psychology: For some useful items consulted, see neurophysiology handbook (Magoun-60); cardiorespiratory functions, handbooks (Altman-58, 59); (Dittmer-58) (Gordon-60); gastro intestinal function (Alvarez). For environmental physiology (Glascick-60). For Physiological and Biological Data for Bioastronautics Handbook, see (U. S. A. F. School of Aerospace Medicine, Brooks A. F. B., Texas, and 19 year cumulative biblio. of research reports issued by Naval School of Aviation (aerospace) Medicine (Daniel-61).

Other Scientific References: See periodic publications as biblios. of following: for electronics (U. S. Army Electronics R & D Lab, Ft. Monmouth), Radiation Effects Info. Center (Battelle-63) 1962 OakRidge National Lab (Johnson-62); (U. S. A. F. European Office of Aerospace Research-62) and basic Research resumés from U. S. A. F. O. A. R. (U. S. A. F. Res. Div. -59), U. S. A. F. Flight Test Center 10 year publications list (Lemmon-63). See also Proc. 5th Ann.

Naval Science Symposium (U. S. O. N. R.): biblios from Aero Establishment (Nat'l Res. Council of Canada-62); translation lists of (Royal Aircraft Establishment, UK-61), science and technol. reports from (Indian Council for Science and Industrial Research).

Selected Military Information Sources: For Limited War problems review by DoD task group, see (U. S. DoD. Director of Defense Research and Eng'g-61A). For limited war biblio (Halperin-61).

For Guerilla Warfare, see (U. S. C. I. A. -50, 62) (Virgil-60, 61), Fort Sill biblio (Hollowar-62), Marines biblio (Johnstone-61), Air Force biblio (U. S. A. F. Acad. Lib. -61) and (U.S. Army Field Manual F. M. 31-21). For others on counter-insurgency, biblio (Vigneras-62), Marine biblio (U. S. M. C. -62) (Condit-63), DoD. biblio. (U. S. J. C. S. Spcl. Ass't for Ctr.-Insurg. -62); training biblio (Osanka-62A) (Hosmer-63). Others on special warfare, biblio (U. S. Army Spcl. Warfare School-62) and Fort Sill Biblio (Holloway-61), operation against irregular forces (F. M. 31-15), Ranger training (F. M. 21-50), evasion and survival (Green-57), theory of search for conscious evader (Norris-62).

For other sources; jungle operations (F. M. 31-30); mountain operations (F. M. 31-72); psychological operations biblio (U. S. Army Spec. Opers. Res. Ofce. -60). Unconventional war concepts (Condit-56) and biblio (Miller-61). For counter-guerilla action by air, see (Osanka-62B), and for visual target acquisition from armored helicopter (Thomas-62). For military small group performance in isolation and stress, see (Sells-61), factors relating to successful and unsuccessful unit action (McKay-59), and for military leadership biblio. (Ruch-53).

For related Asian regional data, see Asian Guerilla movements (Hanrahan-53) and biblio. from (Army) operations Research Office (U. S. O. R. O. -54), anti-guerilla action in S. E. Asia (U. S. Navy-62). For earlier military actions in three Asian theaters, see (Barchan-O. R. O. -53), S. E. Asia (Human Relations Area Files, at Yale). For Laos communist strategy, see (Halperin-RAND) and Indonesian communist tactics (Parker-RAND-60); for S. E. Asia Combat Team Studies, see (Clark-58).

G. SUGGESTED FURTHER WORK

A useful extension of this survey, its sources and findings, can include the areas of study highlighted below. We have starred(*) those which appear most promising. These specific recommendations made do not rule out the further analysis in depth of all of the major areas touched on, and the continuing contact with the literature and active workers in each field. That further broad scale analysis is the major way to obtain all of the information needed to complete a proper comparative evaluation of the possibilities presented.

Recommendations include review efforts, analyses, or experiments, either in support of a primary concept(sebum analysis data), or in test of the primary concept itself(EG. controlled experiments on biosensing of sebum, or of dog tracking of sebum trails). The work suggested here may be intended to make up for data deficiencies in the literature, or to present a positive outlook towards the testing of a good prospective detection concept. Where experiments are suggested, it is assumed that they will not take an inordinate amount of experimenter time and skill, that apparatus can be assembled or designed fairly easily.

On Human Attributes:

1. Assemble a collection of foreign medical teaching texts, hospital manuals, lab data books, published locally in principal geographic regions of interest, and containing indigenous "normal value"data, on urine, feces, sweat. These would be books in biochemistry, clinical lab analysis, pathological physiology, etc.

2. Carry out gas chromatographic analytic separation of whole sebum from skin of various ethnic groups, fresh and after bacterial decomposition; for use in identifying sebum components, maintaining a sebum "fingerprint" library, and making available sebum materials for sensing experiments and tracking studies.

3. Conduct simple experiments on the remote observation of disturbance by man of natural magnetic and electric field patterns, as indicated within report.

*4. Conduct experiment on the observation by ESR(Electron Spin Resonance) techniques of the free radicals which may be produced by intact human skin, after excitation with UV radiation, in suitably designed equipment, and after the manner of the successful isolated skin experiments herein.

5. Make simple spectral reflectance measurements on skin of a much broader variety of ethnic groups of interest, than now found in the literature (as sampled in this report), using wide-band (Middle-UV to middle-IR) spectrophotometer, compact recording type of commercial design.

6. Assemble data on spectral reflectance, UV through IR of current clothing and special forces combat equipment, or representative samples of enemy equipment(where such measurements are not available from QMRE, ERDL, Naval Materials Lab, supplement with measurements made as in 5 above.

7. Assemble tables of "normal values", urine, feces, sweat, from the special information sources set down in 1.

8. Carry out comparative analyses of the "normal values"data from 7 above, and "North Atlantic Normal" data as found in sources contributing to the table in this report;to unearth significant differences in specific fractions, or in concentration profiles.

9. Assemble data on human reflectance and scattering of x-rays, over a wide energy band, as available from diagnostic and therapeutic radiology and health physics reference sources.

10. Review suitable literature to establish validity of hypothesis that human tissue trace mineral composition is a function of soil mineral content in the region where the human spent his years to maturity.

Environmental Background

*11. Assemble data on plant contributions to the chemical background in air, from measurements of Dugway Proving Ground, other sources cited within report.

12. Arrange to receive airborne material chemical and biological samples, from regional environments of interest, either through any systematic collection and surveillance measurements made by CBR Agency, PHS, or Army Surgeon General; etc; or by providing collection equipment as extra job for assigned special forces personnel.

13. Carry out comparison of human product components and concentrations, with those from animal and plant sources (listed in report) and with plant and general environment substances in 11 and 12 above; to unearth human products which are entirely unique or have high concentration ratios (human products/other products).

Sensing

*14. Conduct simple experimental series, with isolated tissue materials set up as biosensors, and exposed to selected human products. Series can include: frog skin and electrical measurement; guinea pig intestine, heart, aorta strip with mechanical contraction measurement; exposure to whole sebum or its fractions, etc. See description in report of these biosensors.

*15. Carry out simple similar experiments using selected chemoreceptor isolated preparations, arranged for electrical measurement; using for example: antenna of silkworm moth, parts of blowfly, etc. Stimuli can be as in 14 above.

*16. Carry out experiments in attempy to sensitize guinea pigs to human sebum and some of its fractions (from individuals and pooled sebum). If serological methods show this to be successful, prepare isolated intestine strips from some of these sensitized animals, for experiments as in 14 above, but seeking enhanced response to sebum.

17. Carry out comparative analysis to match up list of known human excreted products, with their counterparts in proven specific chemosensitivities of good chemoreceptor preparations, to obtain more suitable preparations for experiments as in 15 above.

*18. Carry out short analysis of the several possibilities for ESR (Electron Spin Resonance) observation by remote means. Maintain surveillance over the work cited in report being attempted on non-contact ESR studies for signals from nerve.

19. Carry out analysis of possibilities for detection of characteristic X-ray signal return from humans, in conjunction with search for very high intensity developmental X-ray sources (perhaps x-ray lasers).

*20. Prepare a good theoretical systems model, using the concepts outlined in the report, which would be useful in common for systems detecting either physical or chemical attributes, and employing physical, chemical, or biological sensing; and test out this model for predictive capability for sensitivities needed of detectors for various effects, etc.

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DAILY VARIATIONS IN PHYSIOLOGICAL VALUES FOR EUROPEAN AND
ASIAN MEN WORKING AT HIGH TEMPERATURES IN THE TROPICS
ZZMED RES COUNCIL, LOND

RNP REP NO 53/749 53

ADAMS J A CHAMBERS R W
RESPONSE TO SIMULTANEOUS STIMULATION OF TWO SENSE MODALITIES
J EXP PSYCHOL 63 198 62

ADAMS T RENNIE D
THE COMPARATIVE TOLERANCE OF NEGROES AND CAUCASIANS TO A
STANDARDIZED COLD STRESS AS INDICATED BY BODY TEMPERATURE
AND METABOLIC RATE
ZZARCTIC AEROMED LAB
TR 57-20 SEPT 57

ADES H DAVIS H
AN EXPLORATORY STUDY OF THE BIOLOGICAL EFFECTS OF NOISE
ZZTHE U OF CHICAGO, CHICAGO, ILL
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BENOX REPORT DECEMBER 1 53

ZZADMIRALTY RES LAB AND TELECOMMUNICATIONS RES ESTAB
ATMOSPHERIC TRANSMISSION IN THE 1-14 MICRON REGION
ARL/R4/E600 DEC 50

ADOLPH E
PHYSIOLOGY OF MAN IN THE DESERT
INTERSCIENCE, NY 47

ADRIAN E
OLFACTORY ADAPTATION
J PHYSIOL LOND 112 38 50

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ODORS AND SENSE OF SMELL, A BIBLIOGRAPHY
52

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EVAPORATIVE RATE PATTERNS FROM SMALL SKIN AREAS AS MEASURED
BY AN INFRARED GAS ANALYZER
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MEPHITIS MEPHITICA
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ALEKSEEVSKII E
ANALYTICAL CHEMISTRY BY SMELL
TRUDY LENINGRAD KHIM TEKH INST USSR 10 116 41

ALEXANDER A EWER D
A CHEMORECEPTOR IN THE SCORPION
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ALEXANDER H CHILES W

AN EXPLORATORY STUDY OF PROLONGED INTERMITTENT PHOTIC
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BIOMAGNETICS
ZZNO AMER AVIA, SPACE INFO SYS DIV, L.A., CAL
61

ALEXANDER H
BIOMAGNETICS - THE BIOLOGICAL EFFECTS OF MAGNETIC FIELDS
AMER J MED ELECT 1 181 62

ALLEE W
PRINCIPLES OF ANIMAL ECOLOGY
SAUNDERS, PHILA 49

ALLEN F
ON THE CRITICAL FREQUENCY OF PULSATION OF TONES
PHIL MAG 47 941 24

ALLEN S
TABLE OF MASS ABSORPTION COEFFICIENTS FOR X-RAYS AND
GAMMA RAYS
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CHEMICAL RUBBER PUB 52

ALLEN W
OLFACTORY AND TRIGEMINAL CONDITIONED REFLEXES IN DOGS
AM J PHYSIOL 118 532 37

ALLISON J
DIETARY PROTEINS IN HEALTH AND DISEASE
60

ANNOTATIONS OF SMALL GROUP RESEARCH STUDIES
ALTMAN I PENDLETON C TERAUDS A
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SOUTH AFRICAN FROG XENOPUS LAEVIS
Z VERGL PHYSIOL 45, 272 62

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INTRODUCTION TO GASTROENTEROLOGY
HOEBER, NY XX

AMDUR M
PHYSIOLOGICAL RESPONSE TO ATMOSPHERIC POLLUTANTS
AM INDUST HYG ASSN J 22 1 61

AMER COMM FOR INTERNATIONAL WILDLIFE PROTECTION
THE PRESENT STATUS OF THE MUSK OX IN ARCTIC NORTH AMERICA
AND GREENLAND
39

AMER CONF OF INDUST HYGIENE
AIR SAMPLING INSTRUMENTS
62

AMERICAN GEOGRAPHICAL SOCIETY
WHITE SETTLERS IN THE TROPICS
XX

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ANIMAL SOUNDS AND COMMUNICATION
XX

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DISEASES AND PESTS OF ECONOMIC PLANTS OF INDOCHINA
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AGRICULTURAL PRACTICES OF CENTRAL AND SOUTH CHINA, HONG KONG
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EXPERIMENTAL FINDINGS ON ODOR AND OLFACTION
AMER PERFUM AND COSMET 76 39 61

ANDERSON A
THE SENSITIVITY OF THE LEGS OF COMMON BUTTERFLIES TO
SUGARS
J EXP ZOOL 63 235 32

ANDERSON A MUNSON W
ELECTRICAL EXCITATION OF NERVES IN THE SKIN AT AUDIO-
FREQUENCIES
J ACOUST SOC AMER 23 155 51

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APPLICATIONS OF INFARED SPECTROSCOPY VI RECENT DEVELOPMENTS IN TECHNIQUES OF INCREASED SENSITIVITY FOR THE ANALYSIS OF GAS LIQUID CHROMATOGRAPHY FRACTIONS AND OTHER SMALL SCALE SAMPLES
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THE SWEET TASTE FIBRES OF THE DOG
ACTA PHYSIOL SCAND 21 105 50

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A FILM PROCESS FOR THE INFARED SPECTROPHOTOMETRIC MEASUREMENT IN BIOLOGICAL MATERIAL
BIOCHEM Z 335 212 61

ANDRES L
MAGNETOTROPISM IN PLANTS
NATURE 185 132 60

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THE DISTRIBUTION AND ABUNDANCE OF ANIMALS
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ANIKINA N
ON THE ADAPTATION OF CHEMORECEPTORS
BULL EKSP BIOL MED, USSR 50 24 60

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RELATIVE MICROWAVE ABSORPTION CROSS SECTIONS OF BIOLOGICAL SIGNIFICANCE
PROC FOURTH ANNUAL TRI-SERVICE CONF BIOL EFFECTS MICROWAVE RADIATION 1 153 60

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PENETRATION AND THERMAL DISSIPATION OF MICROWAVES IN TISSUES
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THE INFLUENCE OF DIFT ON FECAL LIPIDS IN SOUTH AFRICAN WHITE AND BANTU PRISONERS
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FACTORS INFLUENCING DERMAL LOSS OF IRON IN HUMAN VOLUNTEERS
IND J MED RES 50 817 62

ARAB Y
BEHAVIORAL RESPONSE TO ELECTRICAL STIMULATION OF
CHEMORECEPTORS IN THE BLOWFLY
J INSECT PHYSIOL 2 324 58

ARCTANDER S
PERFUME AND FLAVOR MATERIALS OF NATURAL ORIGIN
PUB BY AUTHOR, ELIZABETH, NJ 60

ARIEL M EISHER U
TRACE ANALYSIS BY ANODIC STRIPPING VOLTAMMETRY 1 TRACE
METALS IN DEAD SEA BRINE
J ELECTROANAL CHEM 5 362 63

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AMINES IN BLOOD AND URINE IN RELATION TO LIVER DISEASE
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URIC ACID AND TOTAL AMINO N IN VARIOUS RENAL DISEASE AND IN
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ASHBURN E WELDON R
SPECTRAL DIFFUSE REFLECTANCE OF DESERT SURFACES

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OLFACTORY ACUITY IN THE DOG
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PERFUMES AND COSMETICS- THEIR PREPARATION AND MANUFACTURE
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DETECTORS FOR ARGON/
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AYLWARD F
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LIPIDS
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SOME EFFECTS OF NOISE ON HUMAN BEHAVIOR
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ERDL-TULANE SYMPOSIUM ON FLICKER
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AM J PHYSIOL 91 581 29

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FUNDAMENTALS OF INFRARED FOR MILITARY APPLICATIONS
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R-297 56

BAN G
SCATTERED RADIATION IN THE MIDDLE ULTRAVIOLET REGION - APPENDIX 7
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LAS-TR-E174-19 XX

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ANATOMICAL EVIDENCE FOR OLFACTORY FUNCTION IN SOME SPECIES OF BIRDS
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PERFUM AND ESSENTIAL OIL RECORD 48 434 57

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COATINGS WHEN ILLUMINATED BY A LASER
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WITH THE BURCH REFLECTING MICROSCOPE
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EXPERIMENTAL PRODUCTION OF HUMAN CONVULSIVE BRAIN
POTENTIALS BY STRESS-INDUCED EFFECTS UPON NEURAL
INTEGRATIVE FUNCTION - DYNAMICS OF THE CONVULSIVE REACTION
TO STRESS
RES PUBL ASS NERV MENT DIS 29 90 50

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FATIGUE FOLLOWING HIGHLY SKILLED WORK
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VISUAL SENSATIONS AROUSED BY MAGNETIC FIELDS
AMER J PHYSIOL 148 372 47A

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THE EFFECT OF DARK ADAPTATION AND OF LIGHT UPON THE
ELECTRICAL THRESHOLD OF THE HUMAN EYE
AMER J PHYSIOL 148 376 47B

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ON THE POSSIBILITY OF PRODUCING AN INTERPRETABLE VISUAL
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ATTRACTANTS FOR THE WALNUT HUSK FLY
J ECON ENTOM 51 686 58

BARNICOT N
DAILY URINARY 17-KETOSTEROID OUTPUT OF AFRICAN NEGROES
LANCET 1 893 52

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FIRST BIOMAGNETIC SYMPOSIUM, REPORT
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RESPONSES OF THE MUD SNAIL NASSARIUS TO EXPERIMENTAL REVERSALS IN THE DIRECTION OF VERY WEAK MAGNETIC FIELDS
BIOL BULL 121 381 61

BARRUETO R B
MEASUREMENT OF RATES OF EXCRETION OF SWEAT SOLUTES UNDER PHYSIOLOGICAL CONDITIONS
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THE RELATION OF RETINAL ILLUMINATION TO THE EXPERIENCE OF MOVEMENT
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THE NEURAL DETERMINATION OF CRITICAL FLICKER FREQUENCY
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SOME EFFECTS OF INTERMITTENT PHOTIC STIMULATION
J EXP PSYCHOL 25 462 39

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FATIGUE AND IMPAIRMENT IN MAN
MCGRAW-HILL, NY 47

BARTLEY S H
INTERMITTENT PHOTIC STIMULATION AT MARGINAL INTENSITY LEVELS
J PSYCHOL 32 217 51

BARTLEY S
PRINCIPLES OF PERCEPTION
HARPER, NY 58

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SALIENT OPERATIONAL ASPECTS OF PARAMILITARY WARFARE IN THREE ASIAN AREAS -U
ZZARMY, OPERATIONS RES OFF
ORO-T-288 REP SECRET APRIL 53

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AUK 60 271 43

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EFFECT OF A VAPOR BARRIER ON RATES OF EXCRETION OF SWEAT SOLUTES
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MACMILLAN, NY 49

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REIC ACCESSION LIST 60 FEBRUARY 15 63

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SETTING OF AN OLFACTOMETER
PHYS MED BIOL 7 93 62

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/EXPERIMENTS ON SENSE OF SMELL IN THE VIPER/
REV SUISSE ZOOL 34 173 27

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REV SUISSE ZOOL 35 233 28

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THE ESTIMATION OF B AMINOISOBUTYRIC ACID IN HUMAN URINE
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J PSYCHOL 39 157 55

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UEBER DAS AUFTRETEN SUBJECTIVER LICHTEMPFINDUNGEN IN MAGNETISCHEN FELDE
WEIN KLIN WSCHR 15 108 02

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/OLFACTION/
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BEGG M HOGBEN L
CHEMORECEPTIVITY OF DROSOPHILA MELANOGASTER
PROC ROY SOC B 133 1 46

BEHAN J
DOGS OF WAR
SCRIBNERS, NY 46

BEHRENS M
THE ELECTRICAL RESPONSE OF THE PLANARIAN PHOTORECEPTOR
COMP BIOCHEM PHYSIOL 5 129 62

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A THEORY OF TASTE STIMULATION
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ANN OTOL RHINOL LARYNGOL 69 398 60

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EFFECTS OF NEUROHYPOPHYSEAL EXTRACTS ON H2O TRANSFER ACROSS
WALL OF ISOLATED URINARY BLADDER OF TOAD BUFO MARINUS
J ENDOCRIN 17 201 58

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UNUSUAL FOODS FOR HUMAN CONSUMPTION
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BLACKMAN T
OBSERVATIONS ON SENSE OF SMELL IN CHIMPANZEES
AM J PHYS ANTHROP 5 283 47

BLACKWELL H
REPORT OF PROJECT MICHIGAN, OPTICS AND VISION
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AM J PHYSIOL 149 688 47B

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FOR DIFFERENT SUBSTANCES
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BLISS E MIGEON C BRANCH C
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PSYCHOMAT MED 18 57 56

BLOCK B
BIOASSAY OF SYNTHESIZED GYPSY MOTH /P DISPAR/ SEX ATTRACTANT
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AM J PHYSIOL 202 1035 59

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QUELQUES ASPECTS DE L-ETUDE ELECTROPHYSIOLOGIQUE DES RECEPTEURS SENSORIELS DES ANTENNES D-HYMENOPTERES /ISOLATED/
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THE FATTY ACID COMPOSITION OF THE SKIN SURFACE FAT -SEBUM-
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PART FOUR, FIELD EXPERIMENTS ON CANADIAN SPECIES
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FACTORS WHICH ATTRACT AEDES MOSQUITOS TO HUMANS
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RESPONSES OF THE PLANARIAN, DUGESIA, AND THE PROTOZOAN,
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REFLECTION SPECTROPHOTOMETRY
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HUNTING BY SCENT
EYRE AND SPOTTIS WOODE, LOND SECOND ED 37

BUDD A
DETERMINATION OF SILVER ION IN SOLUTION WITH A GLASS
ELECTRODE
J ELECTRO ANAL CHEM 5 35 63

BUETTNER K
/REFLECTANCE OF LIVING AND DEAD SKIN/
STRAHLENTHERAPIE 58 23 37

BUETTNER K
TRANSFER FUNCTION OF HUMAN SKIN
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QUART J MICROSCOPY 98 219 57

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HOUGHTON MIFFLIN, BOSTON 47

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SEBACEOUS SECRETION OF THE HUMAN HEAD
J INVEST DERM 9 67 47

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UNTERSUCHUNGEN UBER WIRKSTOFFE AUS DEM INSEKTENREICH
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/SEXUAL ATTRACTANTS OF BUTTERFLIES AND MOTHS/
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HAFNER, NY 56

CARPENTER R
STUDIES ON THE EFFECTS OF 2450 MEGACYCLES RADIATION ON THE
EYE OF THE RABBIT
PROC THIRD ANNUAL TRI-SERVICE CONF ON BIO EFFECTS OF
MICROWAVE RADIATING EQUIP 279 59

CARPENTER R
AN EXPERIMENTAL STUDY OF THE BIOLOGICAL EFFECTS OF
MICROWAVE RADIATION IN RELATION TO THE EYE
ZZTUFTS U, MEDFORD, MASS
ZZROME AIR DEV CENT, AIR RES AND DEV COMM, GRIFFISS AFB, NY
ZZZ AD275840
TECH NOTE RADC-TDR-62-131 FEBRUARY 62

CARR A

HANDBOOK OF TURTLES
ITHACA, NY 51

CARR D VANLOPIK J
TERRAIN QUANTIFICATION PHASE 1- SURFACE GEOMETRY
MEASUREMENTS
ZZTEXAS INST INC, SCI SERVICES DIV, DALLAS
ZZGEOPHYS RES DIRECTORATE, CAMBRIDGE RES LABS, BEDFORD MASS
ZZZ AD297492
AFCRL-63-208 FINAL REP DEC 31 62

CARREL I, ED
HOUNDS AND HUNTING
DECATUR, ILL 33

CARROLL K
CHARACTER RECOGNITION DEVICES FOR ELECTRONIC COMPUTERS, AN
ANNOTATED BIBLIOGRAPHY
ZZLOCKHEED MISSILES AND SPACE DIV, SUNNYVALE CALIF
ZZZ AD251661
SPECIAL RES BIBLIO SRB-60-11 NOVEMBER 60

CARTHY J
ANIMAL NAVIGATION
SCRIBNERS, NY 56

CASE J GWILLIAM G
AMINO ACID SENSITIVITY OF THE DACTYL CHEMORECPTORS OF
CARCINIDES MAENAS
BIOL BULL 121 449 61

CASE J
RESPONSE OF NEREIS TO ALCOHOLS
COMP BIOCHEM PHYSIOL 6 47 62

CASELLA C RAPUZZI G TACCARDI B
RELATION BETWEEN THE TACTILE AND CHEMICAL SENSITIVITY OF
SINGLE FUNGIFORM PAPILLAE OF THE FROG TONGUE
BOLL SOC ITAL BIOL SPER 37 1403 61

CASIDA J COPPEL H WATANABE T
/SEX ATTRACTANT FROM PINE SAWFLY FEMALE ACTIVE AT NANOGRAM
LEVELS/
J ECON ENTOMOL 56 18 63

CATON J
SENSES OF SIGHT AND SMELL OF THE WILD TURKEY AND THE
COMMON DEER
AM NATURALIST 3 28 70

CATTON W T
THE EFFECTS OF SUBLIMINAL STIMULATION ON THE EXCITABILITY OF
FROG SKIN TACTILE RECEPTORS
J PHYSIOL 164 90 62

CAUNA N MAUVER G
STRUCTURE OF HUMAN DIGITAL PACINIAN CORPUSCLES AND THEIR
FUNCTIONAL SIGNIFICANCE
J ANAT, LOND 92 1 58

CAZZAMALLI F

HETERODYNED RADIATION RETURN FROM HUMAN BRAINS IN RESPONSE TO RF ENERGY
NEUROLOGICA 6 193 25

CHADWICK L DETHIER V
THE RELATIONSHIP BETWEEN CHEMICAL STRUCTURE AND THE RESPONSE OF BLOWFLIES TO TARSAL STIMULATION
J GEN PHYSIOL 30 255 47

CHADWICK L DETHIER V
STIMULATION OF TARSAL RECEPTORS OF THE BLOWFLY BY ALIPHATIC ALDEHYDES AND KETONES
J GEN PHYSIOL 32 445 49

CHALMERS
ATMOSPHERIC ELECTRICITY
BOOK 57

CHAMBERS J DALRYMPLE P
COLOR REGIONS OF THE WORLD
ZZQM RES AND DEV CENT, NATICK, ENVIR PROT RES DIV
ZZZ AD117336
TECH REP EP-37 NOV 56

CHAMBERS J
AN ENVIRONMENTAL COMPARISON OF SOUTHEAST ASIA AND THE ISLAND OF HAWAII
ZZQM RES AND ENG CENT, NATICK
RES REP RER-38 JAN 61

CHANCE B LEGALLIS V
CONTINUOUS FLOW ELECTRON PARAMAGNETIC MEASUREMENT
REV SCI INST 30 732 59

CHAPANIS A ROUSE R O SCHACHTER S
THE EFFECT OF INTER-SENSORY STIMULATION ON DARK ADAPTATION AND NIGHT VISION
J EXP PSYCHOL 39 425 49

CHAPMAN J CRAIG R
AN ELECTROPHYSIOLOGICAL APPROACH TO THE STUDY OF CHEMICAL SENSORY RECEPTION IN CERTAIN INSECTS
CANAD ENTOM 85 182 53

CHAPMAN R
SURVEY AND EVALUATION OF PHENOMENA AND TECHNIQUES IN ULTRAVIOLET, VISIBLE, AND SUBMILLIMETER REGIONS FOR APPLICATION TO DETECTION AND AIDS TO SURVEILLANCE
ZZGEOPHYS CORP OF AMER, BEDFORD
ZZUS AIR FORCE
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REP GCA-61-35A JULY 1 61

CHAPMAN S
DOGS IN POLICE WORK,A SUMMARY OF EXPERIENCE IN GREAT BRITAIN AND THE UNITED STATES
PUBLIC ADMIN SERVICE,CHICAGO 60

CHAPMAN V
THE APPLICATION OF AERIAL PHOTOGRAPHY TO ECOLOGY AS EXEMPLIFIED BY THE NATURAL VEGETATION OF CEYLON

INDIAN FORESTER 73 287 47

CHARNOCK J SMITH C SCHWARTZ C
SERUM MAGNESIUM - CHOLESTEROL RELATIONSHIPS IN THE CENTRAL AUSTRALIAN ABORIGINES AND IN EUROPEANS WITH AND WITHOUT ISCHAEMIC HEART DISEASE
AUST J EXP BIOL MED 37 509 59

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CHATFIELD C
ZZFOOD AND AGRICULTURE ORGANZN, UNITED NATIONS
FOOD COMPOSITION TABLES FOR INTERNATIONAL USE
49

CHEATHAM P
A COMPARISON OF THE VISUAL AND AUDITORY SENSES AS POSSIBLE CHANNELS FOR COMMUNICATION
ZZWADC, WPAFB, OHIO
ZZZ ATI7687
TR 5919 MAY 50

CHEESMAN L
OBSERVATIONS ON THE LAND CRAB,CARDISOMA ARMATUM,WITH ESPECIAL REGARD TO THE SENSE ORGANS
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STUDIES ON THE ANALYSIS OF PURINE AND PYRIMIDINE BASES OF NUCLEIC ACID, PART TWO, A DIRECT SPECTROPHOTOMETER METHOD FOR THE ANALYSIS OF THE PURINE AND PYRIMIDINE BASES IN RIBONUCLEIC ACID
SCIENTIA SINICA 12 673 63

CHERONIS N
FLUORESCENCE MEASUREMENTS TO TEN TO THE MINUS 13 GRAMS PAGE TEN IN SUBMICROGRAM EXPERIMENTATION
INTERSCIENCE 61

CHILES W
EXPERIMENTAL STUDIES OF PROLONGED WAKEFULNESS
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A STUDY OF THE EFFECTS OF THE IONIZED AIR ON BEHAVIOR
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BIOLOGICAL MATERIAL
INDUST AND ENG CHEM /ANAL E 10 619 38

CHOLAK J
THE QUARTZ SPECTROGRAPHIC DETERMINATION OF LEAD IN URINE
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DIPTERA ATTRACTED BY THE SCENT OF CATTLE-DUNG AND URINE
PROC ROY ENT SOC LOND 23 9 48

CHRISTOPHERS S
THE YELLOW FEVER MOSQUITO, AEDES AEGYPTI
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PROBLEMS OF METABOLISM IN SEALED CABINS
PRESENTED AT SECOND SYMPOS, PHYSICS AND MED OF ATMOSPHERE
AND SPACE, SAN ANTONIO TEX NOV 58

CLAPPER P
HOUND THE ENEMY
MARINE CORPS GAZETTE FEB 61

CLARK C VINEGAR R HARDY J D
GONIOMETRIC SPECTROMETER FOR THE MEASUREMENT OF DIFFUSE
REFLECTANCE AND TRANSMITTANCE OF SKIN IN THE INFARED
SPECTRAL REGION
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AN ARMY COMBAT TEAM FOR SOUTHEAST ASIA
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ELEMENTS OF ECOLOGY
WILEY, NY 54

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SPECTROSCOPY
IN ENCYCL OF MICROSCOPY, REINHOLD, NY 60A

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HANDBOOK OF SPECTROSCOPY
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INQUIRES INTO THE ANATOMICAL BASIS OF
OLFACTORY DISCRIMINATION
PROC ROY SOC 146 299 57

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VISUAL BEATS CAUSED BY SIMULTANEOUS ELECTRICAL AND PHOTIC
STIMULATION
AMER J PSYCHOL 70 577 57

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WILEY, NY 39

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THE PASSIVE DYNAMIC MECHANICAL PROPERTIES OF THE HUMAN
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COHEN M HAGIWARA S ZOTTERMAN
THE RESPONSE SPECTRUM OF TASTE FIBRES IN A CAT A
SINGLE FIBRE ANALYSIS
ACTA PHYSIOL SCAND 33 316 55

COLERIDGE G
ANIMAL ATTRACTIONS AND REPULSIONS
CONTEMP REV 117 539 20
COLLINS K
ENDOCRINE CONTROL OF SALT AND WATER IN HOT CONDITIONS
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COMMONER B
ELECTRON SPIN RESONANCE FOR FREE RADICALS IN
LIVING MATERIAL/
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A SYSTEM FOR HANDLING DATA ON UNCONVENTIONAL WARFARE

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DIRECT NESSLERIZATION
AM J CLIN PATHOL 58 634 57

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EXPLOSIONS
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AFOSR TN-K9-551

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CALCIUM IN SWEAT AND ITS POSSIBLE RELATION TO CALCIUM
REQUIREMENTS
J NUTRIT 78 78 62

CONSOLAZIO C NELSON R MATOUSH L
NITROGEN EXCRETION IN SWEAT AND ITS RELATION TO NITROGEN
BALANCE REQUIREMENTS
J NUTRIT 79 400 63A

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EXCRETION OF SODIUM, POTASSIUM, MAGNESIUM AND IRON IN
HUMAN SWEAT AND THE RELATION OF EACH TO BALANCE AND
REQUIREMENTS
J NUTRIT 79 408 63B

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ZZARMY MED RES AND NUTRIT LAB, DENVER
THE NITROGEN EXCRETION IN SWEAT AND ITS RELATION TO
NITROGEN BALANCE AND REQUIREMENTS
REP 270 63C

COOK E
THE INFLUENCE OF INSTRUMENTATION,TISSUE PREPARATION,AND
PERIOD OF DRUG ACTION ON THE RESPONSE OF ISOLATED RABBIT
ILEAL SEGMENTS TO ACETYLCHOLINE

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MILLIMETER WAVELENGTH RADIOMETRY
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OLFACTORY REACTIONS OF THE SPOTTED NEWT, DIEMYCTYLUS VIRIDISCENS
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/SEX ATTRACTANT EXTRACT FROM PINE SAWFLY FEMALE ACTIVE AT NANOGRAM LEVELS/
ANN ENTOMOL SOC AMER 53 510 60

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THE EFFECTS OF NOISE ON HUMAN BEHAVIOR
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ZZANTENNA LAB, OHIO STATE U
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COTT H
ADAPTIVE COLORATION IN ANIMALS
METHUEN, LOND 57

COTTREAU J
L-ODORAT CHEZ LES INSECTS
NATURE, LOND 34-2 39 05

COUJARD R
ETUDE DES GLANDES ODORANTES DE LAPIN ET DE LEUR INFLUENCE MENT PAR LES HORMONES SEXUELLES
REV CANAD BIOL 6 3 47

COWLING T
THE ABSORPTION OF WATER VAPOR IN THE FAR INFRARED
REP PROG PHYS 9 29 43

CRAGG J
REACTIONS OF LUCILIA SERICATA TO VARIOUS SUBSTANCES PLACED ON SHEEP
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REACTIONS OF BLOWFLIES TO ORGANIC SULFUR COMPOUNDS AND OTHER MATERIALS USED IN TRAPS
PARASITOL 40 187 50B

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RADIO TRACKING OF GRIZZLY BEARS
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ABSTRACT FOR NATL GEOGRAPHIC SOCIETY XX

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PHOTOMETER AND ABSORPTION CELL ATTACHMENT FOR
ULTRAMICRO-SPECTROPHOTOMETRY
REV SCI INSTR 24 49 53

CRAIG W
THE DOG AS DETECTIVE
SCIENTIFIC MONTHLY 18 38 24

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ODORS, OLFACTION AND TRAINED ODOR DETECTORS
PROTAR 7 127 41

CRISLER R FENTON A
THE INFRARED SPECTRA OF FATTY ACIDS, SOAPS AND TRIGLYCERIDES
FROM 15-30 MICRONS
PROCTOR AND GAMBLE, CINCINNATI XX
XX

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CHEMICAL BASIS OF GREGARIOUSNESS IN CIRRIPEDES
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COMPREHENSIVE METHOD FOR THE CLASSIFICATION OF ODORS
PROC SCI SECT, TOILET GOODS ASSOC 6 24 46

CROCKER E
THE NATURE OF ODOR
TECH PAP PULP PAP IND NY 35 169 52

CROMBIE A
ON OVIPOSITION OLFACTORY CONDITIONING AND HOST SELECTION
IN RHIZOPERTHA DOMINICA FAB INSECTA COLEOPTERA
J EXP BIOL 18 62 41

CROMBIE A DARRAH J
THE CHEMORECETORS OF THE WIREWORM AGRIOTES SPP AND THE
RELATION OF ACTIVITY TO CHEMICAL CONSTITUTION
J EXP BIOL 24 95 47

CROOK D
A BIBLIOGRAPHY ON DARK ADAPTATION
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SENSITIVITIES OF 10 TO THE THIRTEENTH ELECTRON SPINS BY
ELECTRON SPIN RESONANCE TECHNIQUES
P 152 IN PROGRESS IN NUCLEAR ENERGY, V 2, SERIES 9,
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CROUTHAMEL C
SENSITIVITIES TO 10 TO THE MINUS FIFTEEN GRAM FOR HEAVY
ELEMENTS BY LIQUID SCINTILLATION TECHNIQUES
P 184 IN PROGRESS IN NUCLEAR ENERGY, VOL 2, SERIES 9 61B

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SPECTROPHOTOFLUORIMETRIC STUDIES OF SOME AROMATIC
ALDEHYDES AND THEIR ACETALS
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RAPID SCREENING OF BLOOD SAMPLES FOR VOLATILE POISONS
BY GAS CHROMATOGRAPHY
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IN BIOPHYSICAL RESEARCH METHODS VOL 8
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A FOURTH SENSORY CELL IN BLOWFLY TASTE RECEPTOR
AM ZOOL 1 377 61

DEHN H GUTMANN V
POLAROGRAPHY OF GASES
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THE COMPLETE DOBERMAN PINSCHER
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DENLINGER W
THE COMPLETE BEAGLE
DENLINGER, RICHMOND 56

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COPROPORPHYRIN TOGETHER WITH BASOPHILIC RED BLOOD
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J GEN PHYSIOL 30 247 47B

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BIOL BULL, WOODS HOLE 102 11 52

DETHIER V
OLFACTORY RESPONSES OF BLOWFLIES TO ALIPHATIC ALDEHYDES
J GEN PHYSIOL 37 743 54

DETHIER V
THE PHYSIOLOGY AND HISTOLOGY OF THE CONTACT CHEMORECEPTORS OF THE BLOWFLY
QUART REV BIOL 30 348 55

DETHIER V
CHEMORECEPTOR MECHANISMS
MOLECULAR STRUCTURE AND FUNCTIONAL ACTIVITY OF NERVE CELLS /GRENELL R MULLINS L, EDS/
ZZAM INST BIOL SCI, WASH 56A

DETHIER V WOLBARSHT M
THE ELECTRON MICROSCOPY OF CHEMOSENSORY HAIRS
EXPERIENTIA 12 335 56B

DETHIER V
CHEMORECEPTION AND THE BEHAVIOR OF INSECTS
IN SURVEY OF BIOL PROG VOL 3 B. GLASS ED ACAD PRESS NY 57A

DETHIER V
THE SENSORY PHYSIOLOGY OF BLOOD SUCKING ARTHROPODS /MITES, TICKS, LICE, FLEAS, FLIES/

EXP PARASITOL 6 68 57B

DETHIER V ARAB Y
EFFECT OF TEMPERATURE ON THE CONTACT CHEMORECEPTORS
OF THE BLOWFLY
J INSECT PHYSIOL 2 153 58

DEVEL H
LIPIDS, CHEMISTRY AND BIOCHEMISTRY
INTERSCIENCE 55

DIAMOND J
THE DEPRESSION OF THE RECEPTOR POTENTIAL IN PACINIAN
CORPUSCLES
J PHYSIOL, LOND 141 117 58

DICKE R
THE MEASUREMENT OF THERMAL RADIATION AT MICROWAVE FREQUENCIES
REV SCI INST 17 268 46

DICKSON D
RADIATION ABSORBED BY WATER VAPOR IN THE ATMOSPHERE
ZZUTAH UNIV MET DEPT
ZZAIR FORCE
AN APPROXIMATE METHOD FOR DETERMINING THE AMOUNT OF SOLAR
REP NO 5 53

DIEDERICH H
POLICE AND WORK DOGS IN EUROPE
US DEPT COMMERCE AND LABOR, BUREAU OF MANUF, WASH 09

DIEM K
GEIGY SCIENTIFIC TABLES, SIXTH ED
GEIGY PHARMACEUTICALS, ARDSLEY NY 62
CONTAINS TABLES G AND H

DILL D B
COMPOSITION OF SWEAT DURING ACCLIMATIZATION TO HEAT
AM J PHYSIOL 123 412 38

DITTMER D GREBE R
HANDBOOK OF RESPIRATION
ZZNRC WASH AND USAF DAYTON
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DIXEY F
SCENTS OF BUTTERFLIES
NATURE 87 164 11

DOBSON R ABELE D HALE D
THE EFFECT OF HIGH AND LOW SALT INTAKE AND REPEATED
EPISODES OF SWEATING ON THE HUMAN ECCRINE SWEAT GLAND
J INVEST DERM 36 327 61

DOBSON R
FURTHER STUDIES ON THE HUMAN ECCRINE SWEAT GLAND
ZZU OF OREGON MED SCHOOL, PORTLAND
ZZARMY SURG GENL
ANN REP FEB 15 63

DOELLING N KRYTER K

CHARACTERISTICS OF NOISF PRODUCED BY SEVERAL CONTEMPORARY ARMY WEAPONS
ZZBOLT BERANEK AND NEWMAN, CAMBRIDGE, MASS
RES AND DEV DIV, DEPT OF THE ARMY
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REP NO 630 MARCH 6 59

DOLL R BERKSHIRE J
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DORN F
HUND UND UMWELT, EIN BUCH UBER ALLE FRAGEN DER ZUCHTUNG, HALTUNG AND ERZIEHUNG DES RASSEHUNDES UNTER BESONDERER BERUCKSICHTIGUNG DES GEBRACHSHUNDEWESENS AUFGEZEIGT AM DOBERMANN
DEUTSCHER BAVERNVERLAG, BERLIN 57

DORSEY N
PROPERTIES OF ORDINARY WATER-SUBSTANCE IN ALL ITS PHASES WATER VAPOR, WATER AND ALL THE ICES
REINHOLD PUBLISHING CORP, NEW YORK 40

ZZDOUGLAS AIRCRAFT CO, SANTA MONICA, CALIF
THE DOUGLAS X-BAND MICROWAVE PHOTOTUBE
PAMPHLET NO 2040 MAY 63

DOWNEY F
DOGS FOR DEFENSE,AMERICAN DOGS IN WORLD WAR TWO
MCDONALD NY 55

DRAVNIEKS A
POSSIBLE MECHANISMS OF OLFACTION
NATURE 194 4825 245 62

DRUMMOND A
A NEW APPROACH TO THE MEASUREMENT OF TERRESTRIAL RADIATION
ZZEPPLEY LAB INC., NEWPORT RI
ZZGEOPHYSICS RES DIRECTORATE, AFCRL, BEDFORD, MASS
ZZZ AD265139
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DRUMMOND R LACKEY E
VISIBILITY OF SOME FOREST STANDS OF THE U.S.
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DRYDEN C HANS L HITCHCOCK F
ARTIFICIAL CABIN ATMOSPHERES FOR HIGH ALTITUDE AIRCRAFT
ZZFOR USAF AERO MED LAB, WADC
WADC TECH REP 55-353 56

DUBOIS GAUTIER
THE AFRICAN CIVET AND OTHER VIVIRREDAE
LA FRANCE ET SES PARFUMES 2 3 59

DUGGAN
/SPECTROFLUORIMETRY, URIC ACID/
ARCH BIOCHEM BIOPHYS 68 1 57

DUNKLE R
SPECTRAL REFLECTANCE MEASUREMENTS, SYMPOSIUM, SURFACE EFFECTS ON SPACECRAFT MATERIALS
PAGE 117 IN REP OF FIRST SYMP, WILEY NY 60

DUNKELMAN L
HORIZONTAL ATTENUATION OF ULTRAVIOLET AND VISIBLE LIGHT BY THE LOWER ATMOSPHERE
ZZNAVAL RES LAB, WASH
NRL 4031 SEPT 52

DUNN F
DESTRUCTIVE EFFECT OF SOUND
J ACOUS SOC AMER 29 395 57

DUNTLEY S
THE REDUCTION OF APPARENT CONTRAST BY THE ATMOSPHERE
J OPT SOC AMER 38 179 48

DURVELLE J
THE PREPARATION OF PERFUMES AND COSMETICS
SCOTT, GREENWOOD, LOND 23

DUTKY S SCHECHTER M
ZZUS DEPT AGRICULTURE ENTOMOL RES DIV
MONITORING ELECTROPHYSIOLOGICAL AND LOCOMOTION ACTIVITY
XX

DWIGGINS R
FACTORS AFFECTING SIGNALING BY VISUAL METHODS
ZZCHEM RES DEPT, US NAVAL ORDNANCE LAB, WHITE OAK, MD
ZZZ AD162931
NAVORD REP 6034 DEC 19 57

DWORNIK S ORR D
ZZMINE DETECT, ARMY ENG RES AND DEV, FT BELVOIR, VA
ZZZ AD292994
ZZZ 2381
VARIATION IN REFLECTANCE OF VEGETATION AND SOILS CAUSED BY AN UNDERGROUND NUCLEAR EXPLOSION
FINAL TECHNICAL REP NOVEMBER 1 62

DYSON G
SURVEY OF THE CHEMISTRY OF NATURAL AND SYNTHETIC MUSK SUBSTANCES
CHEM AGE, LOND 24 489 31

EAGLESON C
INSECT OLFACTORY RESPONSES, CONSTRUCTION AND USE OF AN OLFACTOMETER FOR FLIES
SOAP SANIT CHEM 15 123 39

EARLEY W
SUPRESSION OF SCENT IN RABBITS
NATURE 8 78 73

EARP
/SANITARY SIGNIFICANCE OF ODORS/
AMER J PUBL HLTH 13 283 23

EDOZIEN J PHILLIPS E
PARTITION OF URINE NITROGEN IN KWASHIORKOR
NATURE LOND 191 47 61

EDSALL
RAMAN SPECTRA OF AMINO ACIDS AND RELATED COMPOUNDS
J AM CHEM SOC 72 474 50

EDSTROM J
QUANTITATIVE DETERMINATION OF RIBONUCLEIC ACID IN THE MICROMICROGRAM RANGE
J NEUROCHEM 3 100 58

EDWARDS A S
EFFECTS OF THE LOSS OF 100 HOURS SLEEP
AMER J PSYCHOL 54 80 41

EDWARDS D
SOME OBSERVATIONS ON THE EFFECTS ON HUMAN SUBJECTS OF AIR AND STRUCTURE BORNE VIBRATIONS OF VARIOUS FREQUENCIES
ZZFLYING PERSON RES CENT, GT BRITAIN
ZZZ AD115863
SEPT 50

EDWARDS D
EFFECTS OF ARTIFICIALLY PRODUCED ATMOSPHERIC ELECTRICAL FIELDS ON ACTIVITY OF SOME ADULT DIPTERA
CANAD J ZOOL 38 899 60

EDWARDS E A DUNTLEY S Q
PIGMENTS AND COLOR OF LIVING SKIN, REFLECTANCE CHANGE WITH AGE, SEX, RACE
AMER J ANAT 65 1 39A

EDWARDS E A DUNTLEY S Q
/SPECTROPHOTOMETRIC REFLECTANCE MEASUREMENTS TO DETERMINE PIGMENT CHANGES AFTER EXPOSURE TO SUNLIGHT/
SCIENCE 90 235 39B

EDWARDS E
/SPECTROPHOTOMETRY OF LIVING HUMAN SKIN IN UV RANGE/
J INVEST DERM 16 311 51

ELDER T STRONG J
THE INFRARED TRANSMISSION OF ATMOSPHERIC WINDOWS
J FRANKLIN INST 255 189 MARCH 53

ELIZAROV Y U

STUDY OF CHEMORECEPTION IN MITES, AN
ELECTROPHYSIOLOGICAL STUDY OF CHEMORECEPTION IN THE GRYLLUS DOMESTICUS
ZHUR BIOL, USSR NO 14 286 62

ELKINS H
THE CHEMISTRY OF INDUSTRIAL TOXICOLOGY
WILEY, NY 2ND ED 59

ELLER J
BODY ODOR
MED RECORD 154 167 41

ELLICOTT A, ED
ADVANCES IN MASS SPECTROMETRY
MACMILLAN 63

ELLSON D
A REPORT ON DETECTION OF DECEPTION
ZZINDIANA U
ZZOFF NAVAL RES
RES REP 52

ELSASSER W
FAR INFRARED ABSORPTION OF ATMOSPHERIC WATER VAPOR
ASTROPHYS J 87 497 38

EMANUEL S
QUANTITATIVE DETERMINATION OF THE SEBACEOUS GLANDS AND FUNCTION WITH PARTICULAR MENTION OF TWO METHODS EMPLOYED
ACTA DERMAT VENEREOL 77 144 36

EMANUEL S
MECHANISM OF SEBUM SECRETION
ACTA DERMATOL VENEREOL 19 1 38

EMERLING R
VELOCITY MEASURING SYSTEM EMPLOYING MODULATED LIGHT DOPPLER TECHNIQUES
ZZELECTRO-OPTICAL SYSTEMS, PASADENA, CAL
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J ELECTRO CHEM SOC 107 579 60

ENGEN T PFAFFMANN C
ABSOLUTE JUDGMENTS OF ODOR INTENSITY
J EXP PSYCHOL 58 23 59

ENGLAND J SHARPLES N
SOME MEASUREMENTS AT 3.18 CM WAVELENGTHS OF HUMAN TISSUE
NATURE 163 487 49

ENGLAND J
DIELECTRIC PROPERTIES OF THE HUMAN BODY FOR WAVELENGTHS IN THE 1 - 10 CM RANGE
NATURE 166 4220 SEPT 16 50

EOLIAN S ERAMIAN S
ON CHANGES IN THE EXCITABILITY OF THE OLFACTORY ANALYZER DURING THE ACTION OF VARIOUS INDUSTRIAL SUBSTANCES
VESTZ OTORINOLARING 22 40 60

ERIKSEN C
PARTITIONING AND SATURATION OF THE PERCEPTION FIELD AND EFFICIENCY OF VISUAL SEARCH
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WADC TR 54-161 APRIL 54

ESAKOV A
EFFERENT CONTROL OF RECEPTORS /CHEMORECEPTORS OF THE TONGUE/
BULL EXP BIOL MED, USSR 51 237 61

EVANS C L
SWEATING IN RELATION TO SYMPATHETIC INNERVATION
BRIT MED BULL 13 197 57

EVANS D MELLON D
ELECTROPHYSIOLOGICAL STUDIES OF A WATER RECEPTOR ASSOCIATED WITH THE TASTE SENSILLA OF THE BLOWFLY
J GEN PHYSIOL 45 487 62A

EVANS G
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BACTERIAL FLORA OF NORMAL HUMAN SKIN
J INVEST DERMATOL 15 305 50

EVANS R KRANER H SCHROEDER G
ON SITE RADON STUDIES IN SURFACE SOILS PROJECT VELA
ZZEDGERTON, GERMESHAUSEN AND GRIER, BOSTON
ZZU.S. AIR FORCE
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REP NO B-2516 DEC 62C

EVERED D
/FREE AMINO ACIDS IN URINE/
LONDON U, PHD THESIS 54

EVERED D F
THE EXCRETION OF AMINO ACIDS IN THE HUMAN
BIOCHEM J 62 416 56

EWALD H HINTENBERGER H
METHODS AND USES OF MASS SPECTROSCOPY
ZZMAX-PLANCK INST FOR CHEMISTRY, MAINZ
ZZUS AEC, DIV OF TECHNICAL INFORMATION
TRANSLATION AEC-TR-5080 53

EWING G
INSTRUMENTAL METHODS OF ANALYSIS
MCGRAW HILL 60

EYSENCK H
THE DYNAMICS OF ANXIETY AND HYSTERIA
ROUTLEDGE, LOND 57

FAIR WELLS
/ DETERMINATION OF ODOR IN WATER/
WATER WORKS ENG 87 1051 34

FAIR G GEYER J
WATER SUPPLY AND WASTE-WATER DISPOSAL
WILEY NY 54

FALES H PISANO J
GAS CHROMATOGRAPHY OF BIOLOGICALLY IMPORTANT AMINES
ANALYTICAL BIOCHEM 3 337 62

FENNING W
REFERENCE SOURCES IN THE PHYSIOLOGY OF EXTREME
ENVIRONMENTAL TEMPERATURES
ZZENG RES INST, U MICH
ZZARMY ORDNANCE
PROJ 2167 54

FESSARD A
LES ORGANS ELECTRIQUES
TRAIT DE ZOOL 13 1143 MASSON, PARIS XX

FESTER G BERTUZZI F
GLAND SECRETION OF THE ALLIGATOR /YACAROL/
BERICHTE 67 365 34

FESTER G
/ODOROUS SUBSTANCES OF THE ANIMAL KINGDOM/
CIENCIA INVEST /BUENOS AIRES/ 1 111 45

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MEASUREMENTS OF BEHAVIOR-DECREMENT UNDER CONDITIONS
RELATED TO AIRCRAFT FLIGHT
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TASTE BLINDNESS AND VARIATIONS IN TASTE THRESHOLD IN
RELATION TO THYROID METABOLISM
RECENT ADVANCES BIOL PSYCHIAT 3 198 61

FITCHES H
MASS SPECTRA OF SOME STEROIDS
ADVAN IN MASS SPECTROM 2 428 63

FLEISCHMANN L
GESUNDHEITSSCHADLICHKEIT DER MAGNET WECHSELFELDER
NATURWISSEN 10 434 22

FLEROV K
FAUNA OF USSR MAMMALS - MUSK DEER AND DEER
ACAD SCI USSR, MOSCOW 52

FLEMING I
TERRESTRIAL MAGNETISM AND ELECTRICITY
MCGRAW HILL, NY 39

FLETCHER K LEITHEAD A
ALDOSTERONE EXCRETION IN ACCLIMATIZATION TO HEAT
ANN TROP MED AND PARASITOL 55 498 61

FLOCK A WERSALL J
A STUDY OF THE ORIENTATION OF THE SENSORY HAIRS OF THE
RECEPTOR CELLS IN THE LATERAL LINE ORGAN OF FISH, WITH
SPECIAL REFERENCE TO THE FUNCTION OF THE RECEPTORS
J CELL BIOL 15 19 62

FLUGGE C
GERUCHLICHE RAUMORIENTIERUNG VON DROSOPHILA MELANOGASTER
Z VERGLEICH PHYSIOL 20 463 34

FORD A
FOUNDATION OF BIOELECTRONICS FOR HUMAN ENGINEERING
ZNAV ELECTRONICS LAB SAN DIEGO
57

FOREMAN H BROOKS M
STUDIES ON DETECTION OF BIOLOGICAL EFFECTS OF MAGNETIC
FIELDS
LOS ALAMOS SCI LAB REPORTS 2627 94 61

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PHOTOELECTRIC MIXING OF INCOHERENT LIGHT
PHYS REV 99 1691 55

FORRESTER A T
PHOTOELECTRIC MIXING AS A SPECTROSCOPIC TOOL
J OPT SOC AMER 51 253 61

FORSTER G
/SEXUAL ATTRACTANTS OF CRUSTACEA/
J MAR BIOL ASSOC U.K. 30 333 51

FOSTER D
FUTURE PATHWAYS OF OLFACTORY RESEARCH
PROC SCI SECT TOILET GOODS ASS 14 14 50

FOSTER H
/MAGNETIC RESONANCE SPECTROMETRY/
ANAL CHEM 34 255R 62

FOSTER K G
RELATION BETWEEN THE COLLIGATIVE PROPERTIES AND CHEMICAL
COMPOSITION OF SWEAT
J PHYSIOL /LONDON/ 155 490 61

FOULKE E
COMMUNICATION BY ELECTRICAL STIMULATION OF THE SKIN
ZZU OF LOUISVILLE, LOUISVILLE, KY
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FOX W
VISUAL DISCRIMINATION AS A FUNCTION OF STIMULUS SIZE,
SHAPE, AND EDGE GRADIENT
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TECH NOTE NO 132 AUGUST 57

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URINARY EXCRETION OF FIVE-HYDROXYINDOLEACETIC ACID IN WEST AFRICANS
LANCET 1 942 62

FRAENKEL G
THE ORIENTATION OF ANIMALS
DOVER, NY 40

FRANKE E
MEASUREMENT OF THE MECHANICAL IMPEDANCE OF THE BODY SURFACE
ZZUSAF AIR MATERIAL COMMAND
AIR MATERIEL COMM MEMO REP NO MCREXD-695-71C 48

FRANKE E
MEASUREMENT OF THE MECHANICAL IMPEDANCE OF THE BODY SURFACE
J ACOUSTICAL SOC AMER 21 55 49

FRANKE E VON GIERKE H OESTREICHER H
PHYSICS OF VIBRATIONS OF LIVING TISSUES
ZZWRIGHT AIR DEV CENT, OHIO
AF TECH REP 6367 FEB 51A

FRANKE E
MECHANICAL IMPEDANCE OF THE SURFACE OF THE HUMAN BODY
J APPLIED PHYSIOL 3 582 51B

FRANKEN A
INSTINKT UND INTELLIGENZ EINES HUNDES
Z ANGEWAN PSYCHOL, LEIPZIG 10

FRANKS J HOBBS R KEATING P
DC ELECTROLUMINESCENT IMAGE CONVERTER AND/OR INTENSIFIER
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VIGILANCE STRESS
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INFRARED SPECTRAL EMISSIVITY OF TERRAIN
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FREE J BUTLER G
BUMBLEBEES
LONDON 59

FREE L
INFRARED BACKGROUND NOISE MEASURING PROGRAM
ZZNAVAL UNDERWATER SOUND LAB, NEW LONDON
AUG 10 61

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INSENSIBLE PERSPIRATION AND THE GALVANIC SKIN REFLEX
AM J PHYSIOL 111 55 35

FREEMAN N
INFRARED SPECTRA OF SOME LIPOPROTEINS AND RELATED LIPIDS /STEROIDS/
J BIOL CHEM 203 293 53

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AUDITORY SYSTEM RESPONSE TO MODULATED RADIO FREQUENCY ENERGY
ZZGEN ELEC ADVAN ELECTRON CENTER, CORNELL U, ITHACA, NY
JULY 20 61A

FREY A
AUDITORY SYSTEM RESPONSE TO RADIO FREQUENCY ENERGY
J AEROSPACE MED ASSOC AUG 61B

FREY A H
HUMAN AUDITORY SYSTEM RESPONSE TO MODULATED ELECTROMAGNETIC ENERGY
J APPL PHYSIOL 17 689 62

FRIEDLAND S ZIEMBA F ZIMMERMAN
A PROTON RECOIL NEUTRON SPECTROMETER UTILIZING A SEMICONDUCTOR RADIATION DETECTOR
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ANALYT BIOCHEM 2 568 61

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/COLONIC GASES AND DIET/
AM J PHYSIOL 16 468 06

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LOCI OF OLFACTORY END-ORGANS IN THE HONEYBEE
J EXP ZOOL 97 123 44

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GUSTATORY THRESHOLDS FOR SUCROSE AND ELECTROLYTES
FOR THE COCKROACH PERPIPLANETA AMERICANA
J EXP ZOOL 102 23 46A

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THE LOCI AND THRESHOLDS OF CONTACT CHEMORECEPTORS IN
FEMALES OF THE HORSEFLY TADANUS SULCIFRONS MACQ
J EXP ZOOL 103 61 46B

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A CONTRIBUTION TO THE COMPARATIVE PHYSIOLOGY OF CONTACT
CHEMORECEPTION
J COMP PHYSIOL PSYCHOL 41 25 48

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THE LOCI OF CONTACT CHEMORECEPTORS IN INSECTS
AM MIDLAND NAT 41 602 49

FRINGS H HAMRUM C
THE CONTACT CHEMORECEPTORS OF ADULT YELLOW FEVER MOSQUITOES
J NY ENT SOC 58 133 50

FRINGS H BOYD W
EVIDENCE FOR OLFACTORY DISCRIMINATION BY THE BOBWHITE
QUAIL
AM MIDLAND NAT 48 181 52

FRINGS H COX B
THE EFFECTS OF TEMPERATURE AND THE SUCROSE THRESHOLDS OF
THE TARSAL CHEMORECEPTORS OF THE FLESH FLY SARCOPHAGA
BULLATA
BIOL BULL 107 360 54

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MECHANISM OF ACOUSTIC ABSORPTION IN TISSUE
J ACOUST SOC AMER 24 412 52

FRY W
ZZAVAIL FROM COMM ON HEARING AND BIO-ACOUSTICS, NRC WASH,DC
MECHANISM OF ACOUSTIC ABSORPTION IN TISSUE
52

FRYBERGER D
STUDY OF ATMOSPHERIC ELECTRICITY
ZZARMOUR RES FDTN, CHICAGO
ZZUSAF CAMB RES LABS
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SEPT 61

FUJII N
THE BIOCHEMICAL EXAMINATION OF URINE
SOGO IGAKU 13 478 56

FUJIOKA H
URINARY CHANGE FOLLOWING EXERCISE 1 CHANGES IN URINARY VOLUME WITH REFERENCE TO SOME OTHER COMPONENTS, 2 CHANGES IN NA AND K IN REFERENCE TO SOME OTHER COMPONENTS
MIE-IGAKU 4 567 60

FURCHGOTT
/EFFECTS ON ISOLATED AORTA STRIP LENGTH OF TRACES OF BIOCHEMICAL SUBSTANCES
J PHARM EXP THER 108 129 53

GAITO J
ENVIRONMENTAL REQUIREMENTS OF SEALED CABINS FOR SPACE AND ORBITAL FLIGHTS, 3 PERFORMANCE AND HABITABILITY ASPECTS OF EXTENDED CONFINEMENT
ZZNAV AIR MATER CENT, PHILA
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AERIAL SAMPLING BY HELICOPTER - A METHOD FOR STUDY OF DIFFUSION PATTERNS
IND HYG DIGEST 20 27 56A

GARTRELL F CARPENTER S

AERIAL SAMPLING BY HELICOPTER - A METHOD FOR STUDY OF
DIFFUSION PATTERNS
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GARY N
/HONEYBEE SEX ATTRACTANT IN QUEEN MANDIBULAR GLANDS
IDENTIFIED AS DECANOIC ACID DERIVATIVE/
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ON DISCRIMINATING THE RATE OF VISUAL FLICKER AND AUDITORY
FLUTTER
AMER J PHYSIOL 72 521 59

GEE A
CONTROL OF ODORS IN EVACUATION AIRCRAFT
ZZF D SNELL, NY
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AFTR 6565 PT 1 AND 2 51

GEIGER
THE CLIMATE NEAR THE GROUND
HARVARD U PRESS, CAMBRIDGE 57

GELDARD F
THE HUMAN SENSES
WILEY, NY 53

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A BROAD LOOK AT THE PERFORMANCE OF INFRARED DETECTORS
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P-1697 MAY 11 59

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IMPROVED NONDESTRUCTIVE TESTING
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ELECTRODE PROCESSES
ANN REV PHYS AND CHEM 12 XX 61

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THE ATMOSPHERE
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ACTION POTENTIALS RECORDED FROM OLFACTORY RECEPTOR NEURONS
MIT PHD THESIS 61A

GESTELAND R PITTS W
ALLIGATOR OLFACTION
MIT RLE QUART PROG REP 60 226 JAN 15 61B

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CONDORS SENSE OF SMELL
TRANSACT NAT HIST SOC NORTHUMBERL 1 40 04

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THE BIOCHEMISTRY OF INSECTS
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DOGS AT WAR
MACMILLAN NY 44

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NITROGEN PARTITION IN URINE, A STUDY BASED ON THE
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SLANT VISIBILITY
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OF THE COMPOUND EYE OF THE WORKER HONEYBEE

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SPECTROPHOTOMETRY
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FECES
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MOSBY, ST LOUIS 56

GRAF W
TERRITORIALISM IN DEER
J MAMMOL 37 165 56

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MEN UNDER STRESS
BLAKISTON, PHILA 45

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ARCHIV FUR KRIMINAL ANTHROPOL UND KRIMINALSTIK, LEIPZIG 12

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MICROANALYSIS OF SEBUM AND SEBUM-LIKE MATERIALS BY
TEMPERATURE PROGRAMMED GAS CHROMATOGRAPHY
SCAND J CLIN LAB INVEST 14 368 62

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SKIN
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WHY OTHER PEOPLE SMELL
HYGEIA 19 12 41

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LOCAL MEMBRANE CURRENT IN THE OUTER SEGMENTS OF SQUID
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GYMNOTIDS
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PART THREE, HUMAN SKIN AS A BLACK BODY RADIATOR
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PROC TENTH INT CONGR ENTOM 2 293 58

HEDIN P ADACHI R
THE EFFECT OF DIET AND TIME OF FEEDING ON GASTROINTESTINAL
GAS PRODUCTION IN RATS
J NUTR 77 229 62

HEFFERNAN J BARNES D
TECHNICAL PHOTOGRAPHY OF SURFACE MOTION
ZZEDGERTON, GERMESHAUSEN AND GRIER, BOSTON
ZZZ AD273760
REP VUP-2202 PROJECT GNOME JAN 62

HEGGENESS F
GALACTOSE INGESTION AND URINARY EXCRETION OF CALCIUM AND
MAGNESIUM
NUTRIT REVS 18 147 60

HEGSTED D M
THE COMPOSITION OF HUMAN ADIPOSE TISSUE FROM SEVERAL PARTS
OF THE WORLD
AM J CLIN NUTRIT 10 11 62

HELMER O
ESTIMATION OF URINARY CATECHOLAMINES BY MEANS OF STRIP
OF RABBIT AORTA
J LAB CLIN MED 50 737 57

HENDLER E CROSBIE R HARDY J
MEASUREMENT OF SKIN HEATING DURING EXPOSURE TO INFRARED
RADIATION
ZZAIR CREW EQUIP LAB, NAV AIR MAT CENT, PHILA
ZZZ AD125843
REP NAMC-ACEL-332 MARCH 19 57

HENNEMAN R LONG E

,57

A COMPARISON OF THE VISUAL AND AUDITORY SENSES AS CHANNELS FOR DATA PRESENTATION
ZZUS AIR FORCE, DAYTON
ZZZ AD61558
WADC TECH REP 54-363 AUGUST 54

HENNING H
SMELL EXPERIMENTS WITH THE DOG
Z BIOL 70 1 19

HENRY W
DEVELOPMENT OF ANALYTICAL TECHNIQUES FOR THE DETERMINATION OF MINUTE QUANTITIES OF SELECTED ELEMENTS IN BERYLLIUM
ZZBATTELLE MEM INST, COLUMBUS O
ZZBUREAU OF NAVAL WEAPONS
ZZZ AD294406
INTERIM REP NO 3 JAN 11 63

HENRY CHIAMORI
NESSLERIZATION OF AMMONIA FORMED BY UREASE TREATMENT
AM J CLIN PATHOL 59 277 58

HENSEL H IGGO A WITT I
A QUANTITATIVE STUDY OF SENSITIVE CUTANEOUS THERMORECEPTORS WITH C AFFERENT FIBERS
J PHYSIOL 153 113 60

HENSEL H
RECENT ADVANCES IN THERMORECEPTOR PHYSIOLOGY
IN NEURAL ASPECTS OF TEMPERATURE REGULATION, HANNON AND
ZZARCTIC AEROMED LAB
ZZZ AD293130
VIERECK EDS 61

HERCULES W
SHOCK AND VIBRATION ENVIRONMENT BIBLIOGRAPHY
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AUGUST 62

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SINGLE UNIT RESPONSES IN A PRIMITIVE PHOTORECEPTOR ORGAN
J NEUROPHYSIOL 26 215 63

HERON W DOANE B K SCOTT T H
VISUAL DISTURBANCES AFTER PROLONGED PERCEPTUAL ISOLATION
CANAD J PSYCHOL 10 13 56

HERRICK C
NEUROLOGICAL FOUNDATIONS OF ANIMAL BEHAVIOR
HAFNER NY 62

HERRICK J F KRUSEN F H
PHYSIOLOGICAL AND PATHOLOGICAL EFFECTS OF MICROWAVES
ELECT ENGNG 72 238 53

HERSHEY F
HORMONE AND ENZYME MECHANISMS IN SEBACEOUS GLAND EXCRETION
J INVEST DERMATOL 32 1 59

HERTZBERG H EMANUEL I ALEXANDER M

THE ANTHROPOMETRY OF WORKING POSITIONS 1 A PRELIMINARY STUDY
ZZANTHROPOL SECTION, AERO MED LAB AND ANTIOCH COLLEGE
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ZZZ AD110573
WADC TR 54-520 AUG 56

HERZFELD K LITOVITZ T
ABSORPTION AND DISPERSION OF ULTRASONIC WAVES
ACADEMIC PRESS, NY 59

HESS V
BETA RAY IONIZATION FROM THE GROUND
ZZAF CAMB RES CENT
FORDHAM UNIV REP NO 4 53

HESSE R
ECOLOGICAL ANIMAL GEOGRAPHY
WILEY NY 51

HESSEL STUVIER M
THE ABSOLUTE THRESHOLD OF THE HUMAN SENSE OF SMELL
P 159 IN SENSORY COMMUNICATIONS /ROSENBLITH W, ED/ WILEY 61

HESSLER V WESCOTT E
CORRELATION BETWEEN EARTH CURRENT AND GEOMAGNETIC DISTURBANCE
NATURE 184 627 59

HEUTER T
VISCO-ELASTIC LOSSES IN TISSUES IN THE ULTRA-SONIC RANGE
ZZAVAIL FROM COMM ON HEARING AND BIO-ACOUSTICS, NRC WASH 58

HICKS C MATTERS R
THE STANDARD METABOLISM OF THE AUSTRALIAN ABORIGINES
AUSTRAL J EXP BIOL MED SCI 11 177 33

HICKS C MOORE H ELDRIDGE E
THE RESPIRATORY EXCHANGE OF THE AUSTRALIAN ABORIGINE
AUSTRAL J EXP BIOL MED SCI 12 79 34

HILLENDAHL R
REFLECTANCE CHARACTERISTICS OF NEVADA TEST SITE SOILS
ZZUS NAVAL RADIOLOGICAL DEFENSE LAB, SAN FRANCISCO, CAL
ZZZ AD213434
TR USNRDL-265 MAY 6 58

HILSUM C
ATMOSPHERIC ATTENUATION OF INFRARED AND VISIBLE RADIATION
ZZADMIRALTY RES, ENGLAND
REP ARL/R3/E600 48

HIN-CHING-LIU MANEELY R B
SOME CUTANEOUS NERVE ENDINGS IN THE SOFT SHELLED TURTLE OF SOUTH CHINA
J COMP NEUROL 119 381 62

HINDLEY E SMITH J
SPECTROPHOTOMETRIC ANALYSIS OF FOLIAGE OF SOME BRITISH COLUMBIA CONIFERS

PHOTOGRAMMETRIC ENGNG 23 894 DEC 57

HINES H M RANDALL J E
MICROWAVE INDUSTRIAL HAZARDS
ELECT ENGNG 71 879 52

HINGSTON R
THE MEANING OF ANIMAL COLOR AND ADORNMENT
ARNOLD, LOND 33

HIROMICHI MORITA SATORU
GENERATOR POTENTIAL OF INSECT CHEMORECEPTOR
SCIENCE 130 922 59

HOBSON R
SHEEP BLOW-FLY INVESTIGATIONS, PART THREE, OBSERVATIONS ON
THE CHEMOTROPISM OF LUCILIA SERICATA
ANN APPL BIOL 23 845 36

HOCHSCHILD R
DIELECTRIC CONSTANT AND CONDUCTIVITY -- BY MICROWAVES
NON-DEST TESTING 21 115 63

HOCKING B
SMELL IN INSECTS
ZZDEPT OF ENTOMOL, U OF ALBERTA
ZZDEFENSE RESEARCH BOARD, OTTAWA CANADA, DIR BIOSCI RES
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HODGSON E
A STUDY OF CHEMORECEPTION IN AQUEOUS AND GAS PHASES
BIOL BULL 105 115 53

HODGSON E
PROBLEMS IN INVERTEBRATE CHEMORECEPTION
QUART REV BIOL 30 331 55A

HODGSON E LETTVIN J ROEDER K
PHYSIOLOGY OF A PRIMARY CHEMORECEPTOR UNIT
SCIENCE 122 419 55B

HODGSON E ROEDER K
ELECTROPHYSIOLOGICAL STUDIES OF ARTHROPOD CHEMORECEPTION
GENERAL PROPERTIES OF THE LABELLAR CHEMORECEPTORS OF
DIPTERA
J CELL COMP PHYSIOL 48 5 56

HODGSON E
ELECTROPHYSIOLOGICAL STUDIES OF ARTHROPOD CHEMORECEPTION
RESPONSES OF LABELLAR CHEMORECEPTORS OF THE BLOWFLY
TO STIMULATION BY CARBOHYDRATES
J INSECT PHYSIOL 1 240 57

HODGSON E
CHEMORECEPTION IN ARTHROPODS
ANN REV ENTOMOL 3 19 58A

HODGSON E
ELECTROPHYSIOLOGICAL STUDIES OF ARTHROPOD CHEMORECPTION
ILL CHEMORECEPTORS OF TERRESTIAL AND FRESH WATER

ARTHROPODS
BIOL BULL 115 114 58B

HODGSON E
TASTE RECEPTORS
SCI AMER 204 135 61

HOFMANN T
DIE MODERNE PARFUMERIE
J SPRINGER, BERLIN 32 TRANSL EDWARDS, ANN ARBOR 48

HOLBROOK R
OUTLINE OF A STUDY OF FXTRATERRESTRIAL BASE DESIGN
RAND CORP, SANTA MONICA RM-2161 APR 22 58

HOLEMANS K
FAECAL EXCRETION OF CALCIUM AND PHOSPHORUS IN AFRICANS
S AFRIC J LAB CLIN MED 8 145 62

HOLLADAY J
REFERENCES TO RESEARCH ON HIGH-EMISSIVITY SURFACES
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SPECTRAL REFLECTIVITY OF THE EARTHS ATMOSPHERE II, A
CONGERIES OF ABSORPTION CROSS SECTIONS FOR WAVELENGTHS
LESS THAN 3000 ANGSTROMS
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HOLMES T
THE NOSE
THOMAS, ILL 49

HOOVER R
PROCEEDINGS OF BIO-ASSAY AND ANALYTICAL CHEMISTRY MEETING
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OLFACTORY RECEPTORS IN VERTEBRATES
J COMP NEUROL 41 253 26

HOPKINS G

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A SURVEY OF PAST AND PRESENT INVESTIGATIONS OF THE NATURAL EARTH CURRENTS
REP 113 60

HORACEK K CERNIKOSA
EXAMINATION OF LIPIDS IN HUMAN SEBUM BY DISK CHROMATOGRAPHY
BIOCHEM J 71 417 59

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THE ABSORPTION OF SOUND IN HUMID AIR AT LOW AUDIO FREQUENCIES
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HOSHISHIMA K YOKOYAMA S SETO K
TASTE SENSITIVITY IN VARIOUS STRAINS OF MICE
AMER J PHYSIOL 202 1200 62

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REP R-412-ARPA JAN 63

HOSOI T
IDENTIFICATION OF BLOOD COMPONENTS WHICH INDUCE GORGING OF THE MOSQUITO
J INSECT PHYSIOL 3 191 59

HOWARD J
ABSORPTION OF NEAR INFRARED BLACKBODY RADIATION BY ATMOSPHERIC CARBON DIOXIDE AND WATER VAPOR
ZZOHIO STATE UNIV RES FOUND
REP 1 FOR DA-407 50

HOWARD J WILLIAMS D BURCH D
NEAR-INFRARED TRANSMISSION THROUHGH SYNTHETIC ATMOSPHERES
ZZGEOPHYS RES DIRECTORATE
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SUN-SAND AND SURVIVAL, AN ANALYSIS OF SURVIVAL EXPERIENCES IN DESERT AREAS
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ADTIC PUB D-102 JAN 53

HOXIE W
SENSE OF SMELL IN AMERICAN VULTURES, SENSE OF SMELL IN BLACK VULTURES
ORNITHOL 12 61 AND 12 132 87

HOYT F
METHOD OF MEASURING RELATIVE INTENSITIES IN THE X-RAY
SPECTRUM /FOR X-RAY SPECTROSCOPY/
CASE INST, PHYSICS THESIS

HSU E
A FACTORIAL ANALYSIS OF /HUMAN/ OLFACTION
PSYCHOMETRIKA 11 31 46

HUBBS C
ZOOGEOGRAPHY
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CHOLERA AND THE SODIUM PUMP/MEASURED ELECTRICALLY IN
ISOLATED FROG SKIN/
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HUMPHRY A E GADEN E L JR
AIR STERILIZATION BY FIBROUS MEDIA
INDUST ENG CHEM 47 924 55

HUNT C
ON THE NATURE OF VIBRATION RECEPTORS IN THE HIND LIMB OF
THE CAT
J PHYSIOL LOND 155 175 61

HURSH J
THE NATURAL RADIOACTIVITY OF MAN
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IN PROC OF MEETING BIO ASSAY AND ANAL CHEM, AEC NLCO 5-95,55

HUSAIN A
THE NUTRITION PROBLEM OF THE VILLAGER, INDIA, STUDIES IN
VILLAGE PROBLEMS. BOMBAY, CALCUTTA, MADRAS
LONGMANS 51

HUSSAIN R PATWARDHAN V
IRON CONTENT OF THERMAL SWEAT AND IRON DEFICIENCY ANEMIA
LANCET 276 1073 59

HUSSAIN R
DERMAL IRON LOSS IN HEALTHY INDIAN MEN
IND J MED RES 48 235 60

IAMPIETRO P
VOLUNTARY DEHYDRATION DURING PROLONGED DESERT OPERATIONS
ZZQM RES AND ENG CENT, NATICK
ZZARMY PANEL MEETING ON ENVIRONMENTAL PHYSIOLOGY
OCT 6 59

IDLER D FAGERLUND U MAYOH H
OLFACTORY PERCEPTION IN MIGRATING SALMON I L SERINE
A SALMON REPELLENT IN MAMMALIAN SKIN
J GEN PHYSIOL 39 889 55

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APPARATUS FOR TESTING CHEMOTROPIC RESPONSES OF FLYING INSECTS
J ECON ENTOMOL 36 108 43

INGRAM W
AN INVESTIGATION OF THE TREATMENT OF CABIN CRUISER WASTES
SEWAGE AND INDUSTRIAL WASTES 28 93 JAN 56

INGRAM W
SKIN EXCRETIONS /ENGINEERING BIOTECHNOLOGY OF HANDLING WASTES RESULTING FROM A CLOSED ECOLOGICAL SYSTEM/
ZZNYU COLL ENGNG
ZZAEROMED DIV, AF OFFICE OF SCI RESEARCH
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CONTAINS TABLE T

INGRAM W
ORIENTATION OF RESEARCH NEEDS ASSOCIATED WITH ENVIRONMENT OF CLOSED SPACES
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ZZAIR RES DEV COMM
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THE ENGINEERING BIOTECHNOLOGY OF HANDLING WASTES RESULTING FROM A CLOSED ECOLOGICAL SYSTEM
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PRESENTED AT AAAS SYMPOSIUM ON CLOSED ECOL SYSTEM
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JAN 61

INGRAM W
MICROFIOLOGICAL WASTE TREATMENT PROCESSES IN A CLOSED
ECOLOGY
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INHOFFEN H
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REMOTE SENSING OF ENVIRONMENT
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ELECTROSTIMULATION TECHNIQUES OF HEARING
AF 30/602/3051 63

ISHIKAWA S
RESPONSES OF MAXILLARY CHEMORECEPTORS IN THE LARVA OF THE
SILKWORM, BOMBYX MORI, TO STIMULATION BY
CARBOHYDRATES
J CELL COMP PHYSIOL 61 99 63

ISHIZAWA M
POLAROGRAPHIC STUDY ON THE EXCRETION OF URINARY CALCIUM
IN PATIENTS
KYUSHU J MED SCI 12 27 62

ISRAEL H
RADIOACTIVITY OF THE ATMOSPHERE
P 155 IN COMPENDIUM OF METEOROLOGY, AMER METEOROL SOC 51

IVY A
PHYSIOLOGICAL DIFFERENCES PRODUCED BY RACE AND DIET OTHER
THAN VITAMIN AND MINERAL DEFICIENCIES
PROC HAWAII MED ASSOC APRIL 56

IWATA H
GENETICAL STUDY OF AMINO ACIDS EXCRETED IN URINE
J NAGOYA MED ASSOC 79 37 59

JACKSON E
BATTLEFIELD CASUALTY LOCATOR STUDY
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ATMOSPHERES
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ZZWPAFB AEROSPACE MED DIV
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JACOBSON M
SEXUAL ATTRACTION OF FEMALE GYPSY MOTH
SCIENCE 132 1011 60

JACOBSON M BEROZA M YAMAMOTO R
FEMALE COCKROACH SEX ATTRACTANT, CHEMICALLY IDENTIFIED AND
ACTIVE AT THE THIRTY MOLECULE LEVEL
SCIENCE 139 48 63A

JACOBSON M BEROZA M
CHEMICAL INSECT ATTRACTANTS
SCIENCE 140 1367 63B

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THE SPECTRAL REFLECTIONS OF HUMAN SKIN IN THE REGION
ZZARMY MED RES LAB FT KNOX
255-1000 MILLIMICRONS
REP 159 54

JACQUEZ J A KUPPENHEIM H F DIMITROFF J M
SPECTRAL REFLECTANCE OF HUMAN SKIN IN THE REGION 235-700
MILLIMICRONS
J APPL PHYSIOL 8 212 55A

JACQUEZ J A KUPPENHEIM H F
SPECTRAL REFLECTANCE OF HUMAN SKIN IN THE REGION 235-1000
MILLIMICRONS
J APPL PHYSIOL 7 523 55B

JACQUEZ J A
/SPECTRAL REFLECTANCE FROM RATS AND RABBITS/
J APPL PHYSIOL 8 292 55C

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SPECTRAL REFLECTANCE OF HUMAN SKIN IN THE REGION .7-2.6 U

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JAHN T
CHEMORECEPTION
P 447 IN COMPARATIVE ANIMAL PHYSIOLOGY, PROSSER C, ED
SAUNDERS, PHILA 50

JAMES A
OCCURRENCE OF UNUSUAL FATTY ACIDS IN FECAL LIPIDS FROM
HUMAN BEINGS WITH NORMAL AND ABNORMAL ABSORPTION
BIOCHEM J 78 333 61
CONTAINS TABLE AF

JAMIESON H
ASTHMA DUE TO ODOR OF URINE FECES AND SWEAT
ANN ALLERG 5 234 47

JANAK J
IDENTIFICATION OF ORGANIC SUBSTANCES BY THE GAS
CHROMATOGRAPHIC ANALYSES OF THEIR PYROLYSIS PRODUCTS
P 387 IN GAS CHROMATOG SYMPOS,EDINBURGH 60

JANIS I FESHBACH S
EFFECTS OF FEAR AROUSING COMMUNICATIONS
J ABNORM SOC PSYCHOL 48 78 53

JANSEN M
A REFLECTANCE SPECTROMETRIC STUDY OF ULTRAVIOLET ERYTHEMA
J CLIN INVEST 32 1053 53

JAPAN NAT INST OF NUTRITION
EFFECT OF DIET ON EXCRETION OF 17-KETOSTEROIDS IN URINE
ANN REP 60

JARDETSKY O
(MAGNETIC RESONANCE SPECTROSCOPY,BIOLOGICAL APPLICATIONS)
METH OF BIOCHEM ANAL 9 62

JASKI T SUSSKIND C
ELECTROMAGNETIC RADIATION AS A TOOL IN THE LIFE SCIENCES
SCIENCE 133 443 61

JAVES A WHEATLY V
STUDIES OF SEBUM,THE DETERMINATION OF THE COMPONENT FATTY
ACIDS OF HUMAN FOREARM SEBUM BY GAS LIQUID CHROMATOGRAPHY
BIOCHEM J 63 269 56

JELLINEK P
THE PRACTICE OF MODERN PERFUMERY
INTERSCIENCE NY 54

JOHANNIN-GILLES A VODAR B
THE ABSORPTION SPECTRUM OF WATER VAPOR IN THE SCHUMANN
REGION
PHYS AND RADIUM J 15 223 54

JOHNS T
PURIFICATION AND IDENTIFICATION OF THE COMPONENTS OF
COMPLEX ORGANIC MATERIALS
P 242 IN GAS CHROMATOG SYMPOS,EDINBURGH 60

JOHNSON G SERRANA J LEVY E
APPLICATION OF SKIN RESISTANCE TO PSYCHOPHYSIOLOGICAL STUDIES
ZZAEROMED LAB WADC
REP TR-59-688 59

JOHNSON H M
A NOTE ON THE SUPPOSED OLFACTORY HUNTING RESPONSE OF THE DOG
J ANIMAL BEHAV 4 76 14

JOHNSON J
CONSUMPTION OF OXYGEN BY COMBUSTIBLES IN SUBMARINE ATMOSPHERES
ZZNAV RES LAB
REP MR 882 56

JOHNSON J
NUCLEAR SUBMARINE ATMOSPHERE ANALYSIS AND REMOVAL OF ORGANIC CONTAMINANTS
ZZFUELS BRANCH, CHEM DIV, US NAVAL RES LAB, WASH, DC
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J NUTRIT 42 285 50

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J PSYCHOL 36 207 53

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A HYDROID
J EXPER BIOL 38 579 61

KAHMANN H
SINNESPHYSIOLOGISCHE STUDIEN AN REPTILIEN
ZOOL JAHRB 51 173 32

KALMUS H
THE ORIGIN OF ODORS BY WHICH HONEYBEES DISTINGUISH THEIR COMPANIONS
PROC ROY SOC LOND B140 50 52

KALMUS H
THE DISCRIMINATION BY THE NOSE OF THE DOG OF INDIVIDUAL HUMAN ODORS AND IN PARTICULAR OF THE ODORS OF TWINS
BRIT J ANIMAL BEHAV 3 25 55

KALMUS H HUBBARD S
THE CHEMICAL SENSES IN HEALTH AND DISEASE
THOMAS, SPRINGFIELD 60

KAMM G N BOHM H V
INSTRUMENTATION FOR ULTRASONIC ATTENUATION STUDIES
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PHEROMONES, A NEW TERM FOR A CLASS OF BIOLOGICALLY ACTIVE SUBSTANCES
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ANN REV ENTOMOL 4 39 59

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HUMAN FACTORS STUDY OF DESIGN CONFIGURATIONS FOR THE LASER RANGE FINDER
ZZPITMAN-DUNN LABS
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REP R-1664 FEB 63

KASEMIR H
AN APPARATUS FOR SIMULTANEOUS REGISTRATIONS OF POTENTIAL GRADIENTS AND AIR-EARTH CURRENT
J ATMOSPHERE TERREST PHYS 2 32 51

KATCHMAR L
INDICATORS OF BEHAVIOR DECREMENT
ZZDEPT OF PSYCHOL, UNIV OF MD, COLLEGE PARK
ZZARMY MED RES AND DEV BOARD, WASH
ZZZ AD31305
TECH REP 5 MARCH 16 52

KATSUKI Y
REVIEW OF ELECTROPHYSIOLOGICAL STUDIES ON SENSORY RECEPTOR MECHANISMS
J PHYSIOL SOC JAPAN 23 647 61

KATZ B
INITIATION OF IMPULSES OF STRETCH RECEPTORS IN MUSCLES OF FROG
J PHYSIOL, LOND 111 248 50

KAUFMAN W SWAN A DAVIS H

THERMAL EFFECTS OF SIMULATED NUCLEAR FLASH ON AIRCREW MEMBERS
ZZAEROSPACE MED RES LAB, WPAFB, OHIO
ZZZ AD297960
AMRL MEMO M-25 JAN 63

KAWAHATA A SAKAMOTO H
SOME OBSERVATIONS ON SWEATING OF THE AINO
JAPAN J PHYSIOL 2 166 51

KAWAHATA A TANAKA M
STUDIES ON THE FUNCTION OF HUMAN SWEAT ORGANS
MIE MED J 3 219 53

KAWAHATA A ADAMS T
RACIAL VARIATIONS IN SWEAT GLAND DISTRIBUTION
PROC SOC EXP BIOL MED 106 862 61

KEEFE C
THE COMMON CHEMICAL SENSE AND ITS RECEPTORS
ARCH INT PHARMACODYN 139 547 62

KEEGAN H SCHLETER J HALL W
SPECTROPHOTOMETRIC AND COLORIMETRIC RECORD OF SOME LEAVES OF TREES VEGETATION AND SOIL
ZZOPTICS AND METEOROL DIV, NAT BUR OF STDS
ZZAERIAL RECON LAB, WADC, WPAFB
ZZZ AD105798
NBS REPORT 4528 APRIL 56

KEENEY A MELLINHOFF S
COMPONENT MEASUREMENT IN EXPIRED AIR
ANN INT MED 34 331 51

KEHOE R A CHOLAK J STORY R
SPECTRO CHEMICAL STUDY OF THE NORMAL RANGES OF CONCENTRATION OF CERTAIN TRACE METALS IN BIOLOGICAL MATERIALS /FECES/
J NUTRIT 19 586 40

KEITHER W
THE FORMULATION OF COSMETICS AND COSMETIC SPECIALTIES
DRUG COSMETIC INDUSTRY PUB 56

KELLOGG R
OLFACTORY SENSE
/IN HISTORY OF WHALES, THEIR APPLICATION TO LIFE IN THE WATER/
QUART REV BIOL 3 198 28

KELLY E, ED
ULTRASOUND IN BIOLOGY AND MEDICINE
ZZAMER INST OF BIOL SCI, WASH
SYMPOS OF USAF BIOACOUSTICS LAB AT U OF ILL, 55 57

KELLY M
MEASUREMENT OF NEURON ACTIVITY BY PARAMAGNETIC RESONANCE
ZZPOLYTECH INST OF BROOKLYN
ZZAIR FORCE OFF OF SCI RES
AFOSR 62-295 NOV 9 AD291441 62

KENDEIGH C

ANIMAL ECOLOGY
PRENTICE HALL, NY 61

KENNARD D W
THE NERVOUS REGULATION OF THE SWEATING APPARATUS OF THE HUMAN SKIN AND EMOTIVE SWEATING IN THERMAL SWEATING AREAS
J PHYSIOL 165 457 63

KENNEDY C
SOME NON-NERVOUS FACTORS THAT CONDITION THE SENSITIVITY OF INSECTS TO MOISTURE, TEMPERATURE, LIGHT AND ODORS
ANN ENTOMOL SOC AMER 20 87 27

KENNEDY D
NEURAL PHOTORECEPTION IN A LAMELLIBRANCH MOLLUSC
J GEN PHYSIOL 44 277 60

KENNEDY D BRUNO M
THE SPECTRAL SENSITIVITY OF CRAYFISH AND LOBSTER VISION
J GEN PHYSIOL 44 1091 61

KENNEDY D
THE INITIATION OF IMPULSES IN RECEPTORS
AMER ZOOL 2 27 62

KENNEDY W
INFRARED SENSOR DEVELOPEMENT
ZZTRIONICS CORP, MADISON WISCONSIN
ZZWEAPONS GUIDANCE LAB, AIR RES AND DEV COMMAND, WPAFB OHIO
ZZZ AD234126
FINAL REPORT MARCH 60

KERKA W HUMPHREYS C
TEMPERATURE AND HUMIDITY EFFECTS ON ODOR PERCEPTION
ASHAE TRANS 62 531 56

KERSLAKE D
FACTORS CONCERNED IN THE REGULATION OF SWEAT PRODUCTION IN MAN
ZZR.A.F. INST OF AVIA MED
F.P.R.C. 879 MAY 54

KETTLEWELL H
/INSECT FEMALE ASSEMBLING SCENTS/
ENTOMOLOGIST 79 8 46

KEULEMANS A
GAS CHROMATOGRAPHY
REINHOLD, NY 59

KEYS A BROZEK J
THE BIOLOGY OF HUMAN STARVATION
U OF MINN PRESS, VOLS 1 AND 2 50

KHOLODOV J
ACTION OF AN ELECTROMAGNETIC FIELD ON THE CENTRAL NERVOUS SYSTEM
PRIRODA, USSR 51 104 62
PIRODA 51 104 62

KILGMAN A SHELLEY W

AN INVESTIGATION OF THE BIOLOGY OF THE HUMAN SEBACEOUS
GLAND
J INVEST DERM 30 99 58

KIMURA K BEIDLER L
MICROELECTRODE STUDY OF TASTE RECEPTORS OF RAT AND HAMSTER
J CELL COMP PHYSIOL 58 131 61A

KIMURA K
OLFACTORY NERVE RESPONSE OF THE FROG
KUMAMOTO MED J 14 37 61B

KIMURA K
ADAPTATION OF CHEMORECEPTORS AS ANALYZED BY ACTIVITY IN
SINGLE GUSTATORY FIBERS
KUMAMOTO MED J 14 149 61C

KING S H FUNKENSTEIN D H
RELIGEOUS PRACTICE AND CARDIOVASCULAR REACTIONS UNDER STRESS
J ABNORM SOC PSYCHOL 55 135 57

KIRK E
THE QUANTITY AND COMPOSITION OF HUMAN COLONIC FLATUS
GASTROENTEROLOGY 12 782 49

KIRK P
ULTRAMICROANALYSIS
WILEY, NY 50

KIRK P L
IDENTIFICATION IN THE SUB-MICROGRAM RANGE
MICROCHEM J SYMP SER 1 19 61

KISHIMOTO Y RADIN N
MICRODETERMINATION, ISOLATION AND GAS-LIQUID CHROMATOGRAPHY
OF TWO-HYDROXY FATTY ACIDS
J LIPID RES 4 130 63

KISTIAKOWSKY G
ENZYME THEORIES OF OLFACTION
SCIENCE 112 154 50

KLEMENTYEVS A
INTERFERENCE LIGHT FILTERS FOR THE ULTRAVIOLET REGION OF THE
SPECTRUM
VESTNIK MOSKOV UNIV SER 3, FIZIKA ASTRONOMIYA, P 23
ZZZ AD269635
60

KLIER S LINSKEY J
SELECTED ABSTRACTS FROM THE LITERATURE ON STRESS
ZZNYU COLL OF ENGNG, NY
ZZNAVAL TRAINING DEVICE CENT
ZZZ AD253068
NAVTRADEVCEN 565/1 NOVEMBER 60

KLOEK J
THE SMELL OF SOME STEROID SEX HORMONES AND THEIR METABOLITES
PSYCHIATRIA NEUROLOGIA NEUROCHIRURG 65 309 61

KLOTZ I DOLE M

AN AUTOMATIC-RECORDING ULTRAVIOLET PHOTOMETER FOR
LABORATORY AND FIELD USE
IND ENG CHEM, ANAL 18 741 46

KLUIVER M
BIOPHYSICS OF THE SENSE OF SMELL
STUDENT THESIS GRONINGEN 58

KNESER H
INTERPRETATION OF THE ANOMALOUS SOUND ABSORPTION IN AIR AND
OXYGEN IN TERMS OF MOLECULAR COLLISIONS
J ACOUST SOC AM 5 122 33

KNESTRICK G COSDEN T CURCIO J
ATMOSPHERIC ATTENUATION COEFFICIENTS IN THE VISIBLE AND
INFRARED REGIONS
ZZOPTICS DIV, NAVAL RES LAB, WASH
ZZZ AD263441
NRL REP 5648 AUGUST 8 61

KNOCHE H
DER HUND IM DIENST DER POLIZEI
VERLAG FUR POLIZEI FACHSCHRIFTEN LUBECK 57

KNOX G W
INVESTIGATIONS OF FLICKER AND FUSION III THE EFFECT OF
AUDITORY STIMULATION ON THE VISUAL CFF
J GEN PHYSIOL 33 139 45A

KNOX G W
INVESTIGATIONS OF FLICKER AND FUSION IV THE EFFECT OF
AUDITORY FLICKER ON THE PRONOUNCEDNESS OF VISUAL FLICKER
J GEN PHYSIOL 33 145 45B

KNUDSEN V
THE ABSORPTION OF SOUND IN AIR, IN OXYGEN AND IN NITROGEN -
EFFECTS OF HUMIDITY AND TEMPERATURE
J ACOUST SOC AM 25 835A 53

KODAMA K MIURA Y
RELATION BETWEEN DIET AND INTESTINAL GAS FORMATION
JAPAN SOC FOOD NUTR 2 149 49

KOJIMA N
A STUDY OF THE AMOUNT OF URINARY SULFATES FOR HEALTHY
JAPANESE ADULTS
J OSAKA MED CENT 9 5081 60

KOLSKY H
ELECTROMAGNETIC WAVES EMITTED ON DETONATION OF EXPLOSIVES
NATURE JAN 9 P 77 54

KONECCI E WOOD N
DESIGN OF AN OPERATIONAL ECOLOGICAL SYSTEM
ZZDOUGLAS AIRCRAFT CO, STA MON, CAL
MISSILES AND SPACE SYS ENG REP 861 59

KONIKOFF J REYNOLDS L
STUDY OF THE PURIFICATION OF WATER FROM BIOLOGICAL WASTES
ZZGEN ELEC CO, SPACE SCI LAB, PHILA
ZZNASA, WASH

ANN REP ON NASA CONTRACT NASW 127 OCT 60

KONIKOFF J
SPACE FLIGHT ECOLOGIES
ZZGEN ELECT CO, SPACE SCI LAB, PHILA
ZZZ AD268509
REP NO R61SD200 DEC 61

KONISHI J ZOTTERMAN Y
TASTE FUNCTIONS IN THE CARP
ACTA PHYSIOL SCAND 52 150 61

KOPPANYI T COWAN F F
CATECHOLAMINES AS POSSIBLE STIMULANTS OF CHEMORECEPTOR MECHANISMS
ARCH INT PHARMACODYN 139 564 62

KORNFIELD A HEALER J
BIBLIO OF BIOSENSORS/PART OF A REVIEW OF BIOLOGICAL MECHANISMS FOR APPLICATION TO INSTRUMENT DESIGN/
REP ARA-985 JULY
ZALLIED RES ASSOC BOSTON
ZZNAT AERONAUT + SPACE ADMIN WASH CONTR NASR-16
REP ARA-985 61

KORNFIELD A
BIOSENSING CONCEPTS
ZBIOSEARCH CO BOSTON
ZZARMY BIOL LABS PHYS DEF DIV FT DETRICK
ZZZ AD275381
QTLY PROG REPT MAR 62A

KORNFIELD A
BIOSENSING FOR BW DETECTION VOL 1 DATA AND ANALYSES
ZBIOSEARCH CO BOSTON
ZZARMY BIOL LABS PHYS DEF DIV FT DETRICK
ZZZ AD294874
FINAL REP OCT 62B

KORNFIELD A
BIOSENSING FOR BW DETECTION VOL 2 BIBLIO + SELECTED GRANTS
ZBIOSEARCH CO BOSTON
ZZARMY BIOL LABS PHYS DEF DIV FT DETRICK
ZZZ AD294871
FINAL REP OCT 62C

KORNFIELD A
BIOSENSING FOR BW DETECTION VOL 3 INTERPRETATIONS
ZBIOSEARCH CO BOSTON
ZZARMY BIOL LABS PHYS DEF DIV FT DETRICK
FINAL REPT FEB 63

KOSHTOIANTS T KATALIN R
THE ENZYMATIC BASIS OF TASTING
BIOPHYS USSR TRANSL 3 652 58

KOSHTOYANTS K
COMPARATIVE PHYSIOLOGY OF THE NERVOUS SYSTEM
ST PUBL HOUSE, MOSCOW 60

KRAVKOV S V

ACTION DES EXCITATIONS AUDITIVES SUR LA FREQUENCE CRITIQUE
DES PAPILLOTEMENTS LUMINEUX
ACTA OPHTHAL KBH 13 260 35A

KRAVKOV S V
THE ACTION OF AURAL STIMULI ON FLICKER FUSION
FIZIOL ZH, USSR 19 826 35B

KRAVKOV S V
CRITICAL FREQUENCY OF FLICKER AND INDIRECT STIMULI
CR ACAD SCI, USSR 22 65 39A

KRAVKOV S V
THE INFLUENCE OF ODORS ON COLOR VISIONS
ACTA OPHTHAL KBH 17 426 39

KRINOV E
SPECTRAL REFLECTANCE PROPERTIES OF NATURAL FORMATIONS
IZVEST AKAD NAUK USSR
TRANS TT-439 BY NAT RES COUNC, CANADA 47

KROLAK L DAVIS T
THE MEASUREMENT OF DIFFUSE REFLECTANCE OF CLOTH AND SKIN
SAMPLES
ZZU OF ROCHESTER
ZZATOMIC ENERGY COMMISSION
REP UR-380 55

KRUM J
TRUEST EVALUATIONS IN SENSORY PANEL TESTING
FOOD ENG 74 JULY 55

KRUSE P
ORGANIC COLORIMETRY
ANAL CHEM 25 1188 53

KRUSE P MCGLAUCHLIN L MCQUISTAN R
ELEMENTS OF INFRARED TECHNOLOGY
WILEY, NY 62

KRUSE P BLUE M
INTRINSIC INFRARED DETECTOR RESEARCH
ZZHONEYWELL RESEARCH CENT, HOPKINS, MINNESOTA
AERONAUT SYSTEMS DIV, RECONNAISSANCE LAB, WP-AFB, OHIO
ZZZ AD294884
INTERIM ENGNG REP NO 7 JANUARY 15 63

KRYLOV A TARAKANOVA G
MAGNETROPISM OF PLANTS AND ITS NATURE
PLANT PHYSIOL 7 191 60

KUBOTA K
COMPARATIVE ANATOMICAL AND NEUROHISTOLOGICAL OBSERVATIONS
ON THE TONGUE OF THE GREAT ANTEATER /MYRMECOPHAGA JUBATA
LINNE/
ANAT REC 143 15 62

KULP C ROWLAND G
DAYLIGHT VISUAL TARGET DETECTION
ZZROWLAND, HADDONFIELD, NJ
ZZNAVY AIR CREW EQUIP LAB, NAV AIR MAT CENT, PHILA

ZZZ AD225885
REP 59-1-1 JULY 28 59

KUNO Y
HUMAN PERSPIRATION
THOMAS , SPRINGFIELD 56
CONTAINS TABLE AG

KUPPENHEIM H BEER R
SPECTRAL REFLECTANCE OF WHITE AND NEGRO SKIN BETWEEN
FOUR HUNDRED AND ONE THOUSAND MILLIMICRONS
J APPL PHYSIOL 4 800 52

KUSANO K
ANALYSIS OF THE SINGLE UNIT ACTIVITY OF GUSTATORY
RECEPTORS IN THE FROG TONGUE
JAP J PHYSIOL 10 620 60

LAARMAN J
THE HOST SEEKING BEHAVIOR OF THE MOSQUITO
ANOPHELES MACULOPENNIS

LACHER
(INFRA RED ABSORPTION SPECTRA FOR URACIL,THYMINE)
SCIENCE 110 300 49

LADELL W
THE MEASUREMENT OF CHLORIDE LOSSES IN THE SWEAT
J PHYSIOL 107 465 48

LAIRD D
MANS INDIVIDUALITY IN ODOR
J ABNORMAL AND SOCIAL PSYCHOL 29 459 35

LALOY L
THE ODOR OF EUROPEANS
J MED BRUXELLES 9 388 04A

LALOY L
THE ODOR OF EUROPEANS
J ANTHROPOL MOSCOW 15 119 04B

LANDIS C
AN ANNOTATED BIBLIOGRAPHY OF FLICKER FUSION PHENOMENA
COVERING THE PERIOD 1740 - 1952
ZZPSYCHIATRIC INST, COLUMBIA U, NYC
ZZARMED FORCES NRC VISION COMM, ANN ARBOR
ZZZ AD121183
JUNE 53

LANDGREN S
EXCITATION OF CAROTID PRESSURE RECEPTORS
ACTA PHYSIOL SCAND 26 1 52

LANG L
ABSORPTION SPECTRA(PYRIMIDINES)IN THE ULTRAVIOLET AND
VISIBLE REGION
VOL 3 ACAD PRESS 62

LANYON W TAVOLGA W
ANIMAL SOUNDS AND COMMUNICATION
AMER INST OF BIOL SCI WASH 60

LARMORE L
TRANSMISSION OF INFRARED RADIATION THROUGH THE ATMOSPHERE
ZLOCKHEED AIRCRAFT CORP
RESCH MEMO RM 63-20 56

LAROCCA A ZISSIS G
FIELD SOURCES OF BLACKBODY RADIATION
ZZENGNG RES INST, U OF MICH, ANN ARBOR
ZZZ AD202608
2144-264-T JUNE 58

LARSEN M GANO R NEWMAN M
STUDY OF ELECTRO-MAGNETIC PROPAGATION OF A TRANSIENT SIGNAL
THROUGH SEA WATER
ZZENGNG AND EXPER STATION, COLL ENGNG, U OF FLA
ZZDEPT OF THE NAVY, OFFICE OF NAVAL RESEARCH

ZZZ AD295107
TECHNICAL REPORT NO 2 DECEMBER 62

LASKER G B
PHOTOELECTRIC MEASUREMENTS OF SKIN COLOR IN A MEXICAN MESTIZO POPULATION
AM J PHYS ANTHROP 12 115 54

LAVERACK M
RESPONSE OF CUTICULAR SENSE ORGANS OF THE /LOBOTA/ HOMARUS VULGARIS 1 HAIR PEG ORGANS AS WATER CURRENT RECEPTORS
COMP BIOCHEM PHYSIOL 5 319 62

LAVERACK M
ASPECTS OF CHEMORECEPTION IN CRUSTACEA
COMPAR BIOCHEM PHYSIOL 8 141 63

LAW L BOOTHE R
ZZU TEXAS ELECT ENG RES LAB
A SURVEY OF THE CHARACTERISTICS AND ORIGINS OF GEOMAGNETIC MICROPULSATION
REP 111 59

LAWRENCE A FERGUSON L
EXPLORATORY PHYSICOCHEMICAL STUDIES ON THE SENSE OF TASTE
NATURE, LOND 183 1469 XX

LAYMON R
RELATIONSHIP BETWEEN FLAVOR AND PHYSICO-CHEMICAL PROPERTIES OF COMPOUNDS
ZZBATTELLE MEMORIAL INST, COLUMBUS OHIO
ZZQUARTERMASTER FOOD AND CONTAINER INST, CHICAGO ILL, SPONS
PROGRESS REP NO 1 APRIL 59

LAZARUS R DEESE J OSLER S
THE EFFECTS OF PSYCHOLOGICAL STRESS UPON PERFORMANCE
PSYCHOLOGICAL BULL 49 293 52

LEAF A
PERMEABILITY OF THE ISOLATED TOAD BLADDER TO SOLUTES AND ITS MODIFICATION BY VASOPRESSIN
J GEN PHYSIOL 45 921 62

LEBLANC P
ZZMUSEUM OF SCI AND INDUSTRY, LAB FOR APPLIED SCI, CHICAGO
ZZBUREAU OF NAVAL WEAPONS, WASH
ZZZ AD299549
SYMPOSIUM ON MILITARY APPLICATIONS OF ULTRAVIOLET RADIATIONS
REP LAS-TR-199-37 62

LEDERER
(CHEMICAL COMPOSITION OF SCENT SUBSTANCE CASTOREUM)
BULL SOC CHIM BIOL TRAV 43

LEDERER
(ON ANIMAL PERFUMERY)
INDUSTRIE DE LA PARFUMERIE JULY AUG 46

LEHMANN J F
THE BIOPHYSICAL MODE OF ACTION OF BIOLOGIC AND THERAPEUTIC

ULTRASONIC REACTIONS
J ACOUST SOC AMER 25 17 53

LEIDEN 55
LAARMAN J
THE HOST SEEKING BEHAVIOR OF THE MALARIA MOSQUITO
ARCH NEERL ZOOL 11 529 56

LEIDERMAN P STERN R
SELECTED BIBLIOGRAPHY ON SENSORY DEPRIVATION AND RELATED SUBJECTS
ZZHARVARD MED SCHOOL, BOSTON
ZZBIOMED LAB, WP-AFB OHIO
ZZZ AD268601
ASD TECH REP 61-259 JULY 61

LEIGH A
DEFECTS OF SMELL AFTER HEAD INJURY
LANCET 244 38 43

LEIGHTON A
THE TURKEY VULTURES EYES(AND SCENT)
AUK 45 352 28

LEITHEAD C
WATER AND ELECTROLYTE METABOLISM IN THE HEAT
FED PROC 22 901 63

LEMAGNEN J
UN CAS DE SENSIBILITE OLFACTIVE SE PRESENTANT COMME UN CARACTERE SEXUEL SECONDAIRE FEMININ
COMPT REND 226 694 48

LEMAGNEN J
VARIATIONS SPECIFIQUES DES SEULIS OLEFACTIFS CHEZ L HOMME SOUS ACTIONS ANDROGENE ET OESTROGENE
COMPT REND 49

LEMAGNEN J
THE ROLE OF OLFACTO GUSTATORY STIMULI IN THE REGULATION OF THE ALIMENTARY BEHAVIOR OF THE MAMMAL
J PSYCHOL NORM PATH 56 137 59

LEMAGNEN J
LA VARIATION DES SENSIBILITES OLFACTIVES EN FENCTION DES ETATS PHYSIOLOGIQUFS GENERAUX
THESE DE DOCTORAT ES SCIENCES PARIS 50

LEMAIRE R
/PHYSIOLOGY OF SUDATION/
ARCH BIOL THERMO CLIMAT /PARIS/ 1 7 56

LEMMON G
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AFFTC BIBLIO FTC-TDR-63-5 FEB 63

LENHOFF H BOVAIRD J

REQUIREMENT OF BOUND CALCIUM FOR THE ACTION OF SURFACE CHEMORECEPTORS
SCIENCE 130 1475 59

LENHOFF H
THE PH-PROFILE OF A CHEMORECEPTOR /HYDRA/
AMER ZOOL 2/3/ 424 62

LETAVET A GORDON D
THE EFFECTS OF RADAR ON THE HUMAN BODY
ZZINST OF LABOR HYGIENE AND OCCUPATIONAL DISEASES,USSR
ZZZ AD278172
ASTIA TRANSLATION 60

LENZI M
BIOLOGICAL EFFECTS OF MAGNETIC FIELDS
STRAHLENTHERAPIE 67 219 40

LEONG P
NUTRITIONAL BIBLIO OF MALAYA
U HAWAII PRESS 52

LETTAU H
RESEARCH PROBLEMS IN MICROMETEOROLOGY
ZZARMY ELECTRONIC PROVING GRD, FT HUACHUCA, ARIZ
REP AEPG-SIG-970-29 JAN 60

LEVINE R
EFFECT OF SELECTED PHYSICAL PARAMETERS ON THE TRANSFER THROUGH BIOLOGICAL MEMBRANES OF COMPOUNDS OF VARYING CHEMICAL TYPES
ZBOSTON UNIV SCHL MED
ZZARMY CHEM CORPS EDGEWOOD
ZZZ AD265976
REPORT OF NOV 61

LEVINSTEIN H
INTERIM REPORT ON INFRARED DETECTORS
ZZSYRACUSE UNIV RES INST, SYRACUSE NY
ZZAERIAL RECON LAB, WRIGHT AIR DEVELOPMENT DIV, USAF
ZZZ AD288259
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LEWIS B
DETERMINATION OF FECAL BILE ACIDS
S AFRIC J CLIN SCI 3 316 57

LEWIS C
CONTACT CHEMORECEPTORS OF BLOWFLY TARSI
NATURE, LOND 173 130 54

LEWIS J
SIGHT AND SCENT IN THE TURKEY VULTURE
AUK 45 467 28

LIBERMAN E
ON THE PROBLEM OF THE EFFECT OF THE CONSTANT MAGNETIC FIELD ON THE EXCITATION THRESHOLD ON AN ISOLATED FROG NERVE
BIOFIZIKA USSR 4 505 59

LICKLIDER J

ON JAMMING SPEECH COMMUNICATION WITH COHERENTLY
AMPLITUDE-MODULATED INTERFERENCE
ZZAVAIL FROM COMM ON HEARING AND BIO-ACOUSTICS, NRC WASH,DC
57

LILJESTRAND G
THE PROBLEM OF TRANSMISSION AT CHEMORECEPTORS
PHARMACOL REV 6 73 54

LINDMAN M
NOISE LEVEL LIMITS FOR AVOIDANCE OF DEAFNESS IN SHIPBOARD
MACHINERY SPACES
ZZBUREAU OF SHIPS, WASH DC
ZZZ AD109636
REP NO 371-N-27 NOVEMBER 8 55

LINEHAN D
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GEOMAGNETIC FIELD DATA AND ELECTRIC FIELD PHENOMENA
ATMOSPHERIC AND TERRESTRIAL
ZZBOSTON COLLEGE
ZZAF CAMBRIDGE RES LABS, MASS
AFCRL 62-1143 SEPT 61

LINSDALE J
THE CALIFORNIA GROUND SQUIRREL
U CAL PRESS BERKELEY 46

LINSDALE J
THE DUSKY FOOTED WOOD RAT
U CAL PRESS BERKELEY 51

LINSDALE J TOMICH P
A HERD OF MULE DEER
U CAL PRESS BERKELEY 53

LISSMAN H W
CONTINUOUS SIGNALS FROM THE TAIL OF A FISH GYMNARCHUS
NILOTICUS
NATURE /LONDON/ 167 201 51

LISSMAN H W
ON THE FUNCTION AND EVOLUTION OF ELECTRIC ORGANS IN FISH
J EXP BIOL 35 156 58A

LISSMAN H MACHIN K
THE METHOD OF OBJECT LOCATION IN GYMNARCHUS
NILOTICUS AND SIMILAR FISHES
J EXP BIOL 35 451 58B

LISSMAN H
ECOLOGICAL STUDIES ON GYMNOTIDS
P 215 IN BIOELECTROGENESIS ELSEVIER NY 61

LISSMAN H
ELECTRIC LOCATION BY FISHES
SCIENTIF AMER 208 50 63

LIST C PEET M
SWEAT SECRETION IN MAN
ARCH NEUROL AND PSYCHIATRY 39 1231 38

LLOYD D P
TEMPERATURE AND THE ACTION OF THE SWEAT GLANDS
PROC NATL ACAD SCI 47 358 61

LOBITZ W C DOBSON R L
DERMATOLOGY THE ECCRINE SWEAT GLANDS
ANN REV MED 12 289 61

LOCONTI J ROTH L
COMPOSITION OF THE ODOROUS SECRETION OF TRIBOLIUM CASTANEUM
ANN ENT SOC AMER 46 281 53

LOEB M
A FURTHER INVESTIGATION OF THE INFLUENCE OF WHOLE-BODY
VIBRATION AND NOISE ON THE TREMOR AND VISUAL ACUITY
ZZARMY MED RES LAB, FORT KNOX, KY
ZZZ AD55065
REP NO 165 OCTOBER 22 54

LOEB M
CULTURE OF INSECT TISSUES
CORNELL UNIV 57

LOEWENSTEIN W RATHKAMP R
THE SITES FOR MECHANOELECTRIC CONVERSION IN A PACINIAN
CORPUSCLE
J GEN PHYSIOL 41 1245 58

LOEWENSTEIN W
THE GENERATION OF ELECTRIC ACTIVITY IN A NERVE ENDING
ANN NY ACAD SCI 81 367 59

LOEWENSTEIN W
BIOLOGICAL TRANSDUCERS
SCI AMER 203 98 60

LOHNER L
INDIVIDUAL AND REGIONAL ODOR OF HUMAN BEINGS
ARCH GES PHYSIOL 202 25 24

LOHNER L
/RESEARCH ON OLFACTORY PHYSIOLOGY, OLFACTORY
EFFICIENCY OF POLICE DOGS/
ARCH GES PHYSIOL 212 84 26

LONDON S WEST A
GASEOUS EXCHANGE IN A CLOSED ECOLOGICAL SYSTEM
ZZBIOMED LAB, AEROSPACE MED DIV, AF SC, WPAFB
AMRL-TDR-62-139 DECEMBER 62

LONG C
BIOCHEMISTS HANDBOOK
VAN NOSTRAND NY 61
CONTAINS TABLE 2

LOOFBOUROW J
ULTRAVIOLET ANALYSIS FOR VITAMINS AND HORMONES
VITAMINS AND HORMONES 1 109 43

LORD R COCHRAN W

ZZILL NATURAL HISTORY SURVEY
TECHNIQUES OF RADIO TRACKING WILD ANIMALS
XX

LOWRY O
BIOCHEMICAL EVIDENCE OF NUTRITIONAL STATUS
PHYSIOL REVS 32 431 52

LUCAS C
THE ECOLOGICAL EFFECTS OF EXTERNAL METABOLITES
BIOL REV 22 270 47

LUCAS N
THE PERMEABILITY OF THE HUMAN EPIDERMIS TO ULTRAVIOLET RADIATION
BIOCHEM J 25 57 31

LUDWIG G
THE VELOCITY OF SOUND THROUGH TISSUES AND THE ACOUSTIC IMPEDANCE OF TISSUES
J ACOUST SOC AMER 22 862 50

LUGG J
RENAL EXCRETION OF 17 KETOSTEROIDS BY MEMBERS OF SOME ETHNIC GROUPS IN MALAYA
NATURE LOND 174 1147 54

LUGG W
A STUDY OF THE RELATIONSHIP BETWEEN THE TWENTY FOUR HOURLY URINARY OUTPUTS OF 17-KETOSTEROIDS AND CREATININE AND THE WEIGHTS OF TWENTY ADULT MALE SUBJECTS FROM SIX ETHNIC GROUPS
AUSTRAL J EXP BIOL 35 395 57

LUGT A ROTZ F
OPTICAL SPATIAL FILTERING TECHNIQUES
ZZRADAR LAB, INST SCI AND TECH U OF MICHIGAN, ANN ARBOR
ZZU.S. AIR FORCE
ZZZ AD294553
INTERIM ENGNG REPORT FOURTH AND FIFTH QUARTERS JAN 63

LIU D HUANG P
NORMAL LEVEL OF BLOOD AND URINARY ALPHA KETO ACIDS IN CHINESE
J FORMOSA MED ASSOC 61 714 62

LUKASIK S NOLLE A
HANDBOOK OF ACOUSTIC NOISE CONTROL, VOL 1 PHYSICAL ACOUSTICS
ZZBOLT BERANEK AND NEWMAN
ZZAERO MED LAB, WADC, WP-AFB OHIO
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SUPPLEMENT 1 WADC TR-52-204 APRIL 55

LYBURN E
A COMPARISON OF THE COMPOSITION OF SWEAT INDUCED IN DRY HEAT AND BY WET HEAT
J PHYSIOL 134 207 56

LYON M
THE DOG IN ACTION
ORANGE JUDD PUBL CO NY 50

LYON R
EVALUATION OF INFRARED SPECTROPHOTOMETRY FOR COMPOSITIONAL ANALYSIS OF LUNAR AND PLANETARY SOILS
ZZSTANFORD RES INST, MELANO PARK, CAL
ZZNASA WASH, SPONSOR
NASA TN D-1871 APRIL 63

180

MCAFFEE R
EFFECTS OF CERTAIN STEROIDS ON THE BIOELECTRIC CURRENT OF
ISOLATED FROG SKIN
AM J PHYSIOL 200 797 61

MCCABE L
AIR POLLUTION
MCGRAW HILL NY 52

MCCAIG M
HYSTERESIS METHODS OF NON DESTRUCTIVE TESTING
VOL 3 OF PROGR IN NON DESTRUCT TESTING MACMILLAN NY 61

MCCANCE R WIDDOWSON E
THE CHEMICAL COMPOSITION OF FOODS
CHEM PUBL CO NY 47

MCCANDLESS W ED
CLOSED CIRCUIT RESPIRATORY SYSTEMS SYMPOSIUM
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ZZZ AD242587
WADD TECH REP 60-574 AUGUST 60

MCCOLLUM E
A HISTORY OF NUTRITION
HOUGHTON MIFFLIN BOSTON 57

MCCORD C WITHERIDGE W
ODORS - PHYSIOLOGY AND CONTROL
MCGRAW-HILL, NEW YORK 49

MCCUTCHAN J TAYLOR C
A QUANTITATIVE STUDY OF EVAPORATION FROM THE HUMAN BODY
DURING SHORT EXPOSURES TO VARIOUS TEMPERATURES, HUMIDITIES
PRESSURES, AND MASS VELOCITIES
ZZU OF CALIF, LOS ANGELES, CALIF
ZZAERO MED LAB, WRIGHT AIR DEV CENT, AIR RES AND COMM, WPAFB
ZZZ AD98216
WADC TECH NOTE 55-522 JUNE 55

MCDONOUGH E
MERCAPTANS IN COSMETICS(THE ODOR OF THIOLS)
AM PERFUMER ESSENT OIL 50 445 47

MCDONOUGH R
EMISSIVITY OF MATERIALS NEAR ROOM TEMPERATURE
P 142 IN FIRST SYMPOSIUM ON SURFACE EFFECTS ON SPACECRAFT
MATERIALS WILEY NY 60

MCEVOY-BOWE E
A DIRECT QUANTITATIVE PAPER CHROMATOGRAPHY OF AMINO ACIDS
AND ITS APPLICATION TO THE URINARY EXCRETIONS OF SOME
HUMAN ETHNIC GROUPS
BIOCHEM J 80 616 61

MCEVOY-BOWE E
FAMILY STUDIES OF URINARY BETA-AMINOISOBUTYRIC ACID
EXCRETION TOGETHER WITH AN EXAMINATION OF THE URINARY
EXCRETION LEVELS OF GLYCINE,ALANINE,TAURINE,AND GLUTAMINE
AMONGST CHINESE IN SINGAPORE
ANN HUM GENET 25 331 62

MCGRATH J
HUMAN FACTORS PROBLEMS IN ANTI-SUBMARINE WARFARE, A BIBLIO
OF RESEARCH ON HUMAN VIGILANCE
ZZHUMAN FACTORS RES INC, L.A. CAL
ZZPSYCHOL SCI DIV, DEPT OF THE NAVY
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SUPPLEMENTARY NOTE TO TECH REP 1 APRIL 61A

MCGRATH W D
ANALYSIS OF GASES AND VAPORS BY SPECTROSCOPIC TECHNIQUES
I EMISSION SPECTROSCOPY
TALANTA 8 892 61B

MCINDO N
AN INSECT OLFACTOMETER
J ECON ENTOMOL 19 545 26

MCKAY J CIANCI S HALL C
SOME FACTORS WHICH HAVE CONTRIBUTED TO BOTH SUCCESSFUL AND
UNSUCCESSFUL AMERICAN INFANTRY SMALL UNIT ACTIONS
HUM RES UNIT FT BENNING AND GEORGE WASH U, HUMRRO
ZZDEPT OF THE ARMY
ZZZ AD260994
RESEARCH MEM APRIL 59

MCKEE H RHOADES J WHEELER R
GAS CHROMATOGRAPHIC MEASUREMENT OF TRACE CONTAMINANTS IN A
SIMULATED SPACE CABIN
ZZSOUTHWEST RES INST, SAN ANTONIO
ZZNASA, WASH DC
NASA TN D-1825 MARCH 63

MCLAFFERTY F
MASS SPECTROMETRY OF ORGANIC IONS
ACAD PRESS 63

MCMAHON H O
THERMAL RADIATION FROM PARTIALLY TRANSPARENT REFLECTING
BODIES
J OPT SOC AMER 40 376 50

MCMASTER R
NON DESTRUCTIVE TESTING HANDBOOK
RONALD PRESS NY 59

MCNEIL W
ZAEROMED LAB WADC
URINE EVAPORATOR
WDAC TR-54-94 54

MA L
A SURVEY OF BLOOD CONSTITUENTS OF HEALTHY CHINESE IN HONG
KONG
TRANS ROY SOC TROP MED HYG 56 222 62

MACHIN K E LISSMAN H W
THE MODE OF OPERATION OF THE ELECTRIC RECEPTORS IN
GYMNARCHUS NILOTICUS
J EXP BIOL 37 801 60

MACHMAN M
THE INFLUENCE OF SIZE AND SHAPE ON THE VISUAL THRESHOLD OF THE DETECTABILITY OF TARGETS
ZZBOSTON U, OPTICAL RES LAB, BOSTON MASS
ZZPHOTO RECON LAB, WRIGHT AIR DEV CENT
ZZZ AD25410
TECH NOTE 109 DECEMBER 53

MACKENNA R
/SEBUM SQUALENE CONTENT/
J INVEST DERMATOL 15 33 50

MACKENNA R WHEATLEY V WORMAL A
STUDIES OF SEBUM,SOME CONSTITUENTS OF THE UNSAPONIFIABLE MATTER OF HUMAN SEBUM
BIOCHEM J 52 161 52

MACKWORTH N H
THE BREAKDOWN OF VIGILANCE DURING PROLONGED VISUAL SEARCH
QUART J EXP PSYCHOL 1 6 48

MAGOUN H
HANDBOOK OF PHYSIOLOGY NEUROPHYSIOLOGY SEC 1
AM PHYSIOL SOC, WASHINGTON 60

MAHADERA K
THE ENERGY EXPENDITURE AT REST OF SOUTHERN ASIATICS IN BRITAIN
IND J MED RES 42 181 54

MAIER B BEVAN W BEHAR I
THE EFFECT OF AUDITORY STIMULATION UPON THE CRITICAL FLICKER FREQUENCY FOR DIFFERENT REGIONS OF THE VISIBLE SPECTRUM
AMER J PSYCHOL 74 67 61

MAKAROV P
BIOPHYSICAL PROBLEMS OF THE SENSE ORGANS
RUSSIAN REV BIOL 50 314 61

MAKI A G STAIR R JOHNSTON R G
APPARATUS FOR THE MEASUREMENT OF THE NORMAL SPECTRAL EMISSIVITY IN THE INFARED
J RES NATL BUR STANRD 64C 99 60

MALLETTE F
PROBLEMS AND CONTROL OF AIR POLLUTION
REINHOLD NY 55

MALMO R
CERTAIN PHYSIOLOGICAL CORRELATES OF PSYCHOMOTOR FUNCTIONING
ZMCGILL UNIV CANADA
ZZZ AD247373
JAN 61

MANCINELLI D
A SPACE VEHICLE SIMULATOR AND ATMOSPHERIC CONTROL SYSTEM
AEROSPACE MED 34 261 63

MANGAN G
CHEMICAL COMPONENTS OF THE ODOR OF FISH
PRESENTED FOR THE QM REC AT AMER CHEM SOC BOSTON APRIL 59

MANGINI A
NEW RAMAN SPECTROSCOPIC INSTRUMENTS
ADVAN IN MOLEC SPECTROSCOPY 3 1320 AND 1386 XX

MANN A COUTU A ROSSI E
A COMPARISON STUDY OF PANCHROMATIC AND INFARED AERIAL
PHOTOGRAPHS TAKEN IN LATE FALL AND IN WINTER
ZZWESLEYAN U
ZZU. S. AIR FORCE
ZZZ AD13143
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MANUAL FOR PHOTOINTERPRETERS A COMPARATIVE STUDY OF AERIAL
PHOTOGRAPHY ON INFRARED PANCHROMATIC AND COLOR FILM
ZZWESLEYAN U
ZZU. S. AIR FORCE
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TECH NOTE NO 50 JULY 30 54

MARCHGRABER R DRUMMOND A
A PRECISION RADIOMETER FOR THE MEASUREMENT OF TOTAL
RADIATION IN SELECTED SPECTRAL BANDS
PRESENTED AT INT RAD SYMPOS, OXFORD 59

MARCUS H
OLFACTORY ORGANS OF ANTS
ACTA ZOOL LILLUOANA 2 441 46

MARKOWITZ M
PRACTICAL SURVEY OF THE CHEMISTRY AND METABOLISM OF THE SKIN
BLAKISTON 42

MARQUIS D
REVISED AMR INFRARED MEASUREMENTS PROGRAM
ZZPAN AM AIRWAYS AND RCA SERVICE CO, MISSILE TEST PROJ
ZZAF MISSILE TEST CENT, PATRICK AFB, FLA
ZZZ AD254182
AFMTC-TR-61-4 FEB 28 61

MARSH H
A SURVEY REPORT UNDERWATER SOUND REVERBERATION
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SEPTEMBER 62

MARSHALL J
ON THE SENSITIVITY OF THE CHEMORECEPTORS ON THE ANTENNA AND
FORE TARSUS OF THE HONEY BEE APIS MELLIFICAL
J EXP BIOL 12 17 35

MARTIGNONI M
PROBLEMS OF INSECT TISSUE CULTURE
EXPERIENTIA 16 125 60
MARTZ D SUMNICHT H AUGASON G
QUANTITATIVE SPECTRAL MEASUREMENTS OF SUNLIT BACKGROUNDS
ZZNAV ORD TEST STAT, CHINA LAKE, CAL
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TECH NOTE IDP-95 APRIL 11 56

MASICA B
OMEGATRON GAS ANALYZER
PRACE PRZEMYBLOWEGO INST ELECTRON 1 49 60

MASKALENNO E
THE USE OF ULTRA HIGH FREQUENCIES IN BIOLOGICAL RESEARCH
BIOPHYSICS USSR TRANSL 3 589 58

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IN MILITARY GEOGRAPHY
8412031 75

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THE OLFACTORY AREA AND THE OLFACTORY RECEPTOR PROCESS
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SIMPLE INDIRECT SENSITIVE PROCEDURE FOR THE DETERMINATION OF
NITROGEN /AMMONIA/ AT THE MICROGRAM AND SUBMICROGRAM LEVEL
ANALYT BIOCHEM 3 408 62

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A FEASIBILITY STUDY CONCERNING PERSONNEL SURVIVAL
FLOTATION AND LOCATOR SYSTEM
ZZNAVAL PARACHUTE FACILITY, EL CENTRO, CAL
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MATRIX REP NO 61-11 JUNE 14 61

MATTHES E
SMELL AND TASTE IN THE ANIMAL KINGDOM
ARQUIV MUS BOCAGE 9 17 38

MATTICE M
RESUME OF NORMAL DATA
P 403 IN CHEMICAL PROCEDURES FOR CLINICAL LABORATORIES
LEA AND FEBIGER PHILA

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SANITATION AND PERSONAL HYGIENE DURING AEROSPACE MISSIONS
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MAW M
SUPPRESSION OF OVIPOSITION RATE OF HYMENOPTERA IN
FLUCTUATING ELECTRIC FIFLDS
CANAD J ENTOMOL 93 602 61

MAXWELL J
ZZU OF MISSOURI
ZZARMY CORPS OF FNGRS, WATERWAYS EXP STATION
TEST OF QUANTITATIVE TERRAIN DESCRIPTION SYSTEMS AT FORT
LEONARD WOOD, MO 62

MAY J
ECOLOGY OF HUMAN DISEASE
MD PUBLICATIONS NY 58

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HAFNER NY 61A

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THE ECOLOGY OF MALNUTRITION IN THE FAR AND NEAR EAST
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THE MICROWAVE SPECTRUM OF OXYGEN IN THE EARTHS ATMOSPHERE
ZZLINCOLN LAB, MIT, DIVISION THREE, LEXINGTON MASS
JA NO 2009 CITED IN LINCOLN LAB QPR DIV 3 JAN 63

MEERLOO J
PSYCHIATRIC ECOLOGY
J NERV MENT DIS 127 59

MEGUIN P
LES CHIENS DE FRANCE AU FRONT PENDANT LA GUERRE
REV DHISTOIRE NATURELLE APPLIQUEE PARIS 20

MEIGS P
ENVIRONMENT OF SOUTHEAST ASIA
ZZENVIRON PROT DIV, NATICK QM RES AND DEV LAB, MASS
ZZZ AD20310
REP 219 AUG 53

MEITES L ED
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SIGNIFICANCE OF THE LAWS OF SPEED-VALUE AND STIMULATION-
SUMMATION IN THE TRAILING OF THE DOG
J PSYCHOL U NEUROL 38 258 29

MENZEL E MENZEL R
DIE VERWENDUNG DER REICHFAHIGKEIT DES HUNDES IM DIENSTE
DER MENSCHKEIT
BERLIN 30

MER G BERNBAUM D

THE ATTRACTION OF MOSQUITOES BY HUMAN BEINGS
PARASITOL 38 1 47

MERCHANT D
HANDBOOK OF CELL AND ORGAN CULTURE
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MERRIAM H
ZZU TEXAS DEPT OF ZOOL
LOW FREQUENCY TELEMETRIC MONITORING OF WOODCHUCK
MOVEMENTS
XX

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TECHNIQUES FOR THE DETERMINATION OF VOLATILE COMPONENTS OF
FOODSTUFFS,USE OF GAS CHROMATOGRAPHY AND MASS SPECTROMETRY
PRESENTED FOR QMREC TO AMER CHEM SOC CHICAGO 58

MERRITT C
RECENT DEVELOPMENTS IN THE APPLICATION OF ANALYTICAL
METHODS TO THE EVALUATION OF FLAVOR AND ODOR
PRESENTED FOR QMREC TO NEW ENGLAND SECTION AMER CHEM SOC
CAMBRIDGE 59

MERRITT C
IDENTIFICATION OF FLAVOR COMPOUNDS
IN SYMPOSIUM ON FLAVOR AND ODOR OF FOODS FOR TECHNOL LAB
BUR OF CMCL FISHERIES,GLOUCESTER MASS, AND QMREC 61

METHODS OF BIOCHEMICAL ANALYSIS, GLICK, D, ED ANNUAL VOLS
INTERSCIENCE 63

MIDDLETON A
SMELL,THE PHYSICAL SENSE
PERFUM AND ESSENT OIL RECORD 47 237 56

MILES D LEPPING R
GEOMAGNETIC FLUCTUATION STUDIES
ZZANTI SUB WAR LAB , NAVAL AIR DEV CENT, JOHNSVILLE, PA
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A SELECTED BIBLIOGRAPHY ON UNCONVENTIONAL WARFARE
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PART 1 OCT 61

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(EXPERIMENTS ON SMELL IN BIRDS)
CONDOR 44 3 42

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THE PRESENT STATUS OF CHEMICAL RESEARCH IN ATMOSPHERE
PURIFICATION AND CONTROL ON NUCLEAR-POWERED SUBMARINES

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NRL REP 5465 APRIL 21 60

MIMURA K
ON THE PHYSIOLOGICAL SIGNIFICANCE OF THE EEG CHANGES CAUSED
BY SONIC STIMULATION
EEG CLIN NEUROPHYSIOL 14 683 62

MINNICH D
THE CHEMICAL SENSES OF INSECTS
QUART REV BIOL 4 100 29

MINTZ B STONE L
TRANSPLANTATION OF TASTE ORGANS IN ADULT TRITURUS
VIRIDESCENS
PROC SOC EXP BIOL MED 31 1080 34

MIT LINCOLN LAB, LEXINGTON MASS
RADIO PHYSICS
ZZU.S. AIR FORCE
ZZZ AD296492
QUARTERLY PROGRESS REP, DIVISION 3 JAN 15 63

MITCHELL E
NUTRITION AND CLIMATIC STRESS
THOMAS SPRINGFIELD 51

MITCHELL H EDMAN M
NUTRITIONAL SIGNIFICANCE OF DERMAL LOSSES OF NUTRIENTS IN
MAN,PARTICULARLY OF NITROGEN AND MINERALS
AM J CLIN NUTRIT 10 162 62A

MITCHELL H HAMILTON T
THE DERMAL EXCRETION UNDER CONTROLLED ENVIRONMENTAL
CONDITIONS OF NITROGEN AND MINERALS IN HUMAN SUBJECTS WITH
PARTICULAR REFERENCE TO CALCIUM AND IRON
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ORGANIC ANALYSIS 3 68 INTERSCIENCE 56

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MATERIALS
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SPECTRAL CHARACTERISTICS OF THE THERMAL RADIATION OF AN
ATOMIC EXPLOSION
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THE CHEMICAL SENSES
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THE CHARACTERIZATION OF ODORS
J PHYSIOL, LOND 125 453 54

MONCRIEFF R
ELECTRO OLFACTOGRAMS IN THE RABBIT
AMER PERFUMER 76 24 61

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OLFACTORY ADAPTATION
AMER PERFUM AND COSMET 78 15 63

MONKMAN J
GAS CHAMBER MICROAPPARATUS IN IDENTIFICATION OF AIRBORNE
POLLUTANTS
ANAL CHEM 27 704 55

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THE EFFECT OF ACTIVITY DEPRIVATION UPON EXPLORATORY BEHAVIOR
J COMP PHYSIOL PSYCHOL 66 438 53

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DIFFERENCES IN ULTRASONIC TESTING OF VARIOUS MATERIALS
NON-DEST TESTING 21 121 63

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GENERATOR POTENTIAL OF INSECT CHEMORECEPTOR
SCIENCE 129 922 59A

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INITIATION OF SPIKE POTENTIALS IN CONTACT CHEMOSENSORY HAIRS OF INSECTS II, THE EFFECT OF ELECTRIC CURRENT OF TARSAL CHEMOSENSORY HAIRS OF VANESSA
J CELL COMP PHYSIOL 54 177 59B

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RECEPTOR POTENTIALS RECORDED FROM SENSILLA BASICONICA ON THE ANTENNA OF THE SILKWORM LARVAE, BOMBYX MORI
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TRACE ELEMENT ANALYSIS
MICROCHEM J SYMP SER 1 37 61

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/EXISTENCE OF A MAGNETIC FIELD ABOUT NEURONS/
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MOTOKAWA K SUZUKI K
A NEW METHOD FOR MEASURING FATIGUE
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THE ELECTRIC EXCITABILITY OF THE HUMAN EYE AS A SENSITIVE INDICATOR OF OXYGEN DEFICIENCY
TOHOKU J EXP MED 50 319 49

MOTOKAWA K
FIELD OF RETINAL INDUCTION AND OPTICAL ILLUSION
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RESONANCE IN ELECTRICAL STIMULATION OF THE EYE
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SELECTIVE STIMULATION OF COLOR RECEPTORS WITH ALTERNATING CURRENTS
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DEVELOPMENTAL ANOMALIES ON FRUIT FLIES IN MAGNETIC FIELDS
NATURE 193 1244 62

MULLER N GOLDERSON J
RAPID ANALYSIS OF REACTION MIXTURES BY NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY
J AM CHEM SOC 78 5182 56

MURAOKA J
SHELTER HABITABILITY STUDIES, ODORS AND REQUIREMENTS FOR VENTILATION
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MURATAR T
THE EXCRETION OF AMINO ACIDS IN THE JAPANESE
KUMAMOTO PHARM BULL 7 264 59

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WAVES IN ANIMALS
FIZIOL ZHUR AKAD NAUK UKRAIN SSR 8 382 62B

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ILLUMINATION CONTRAST SPECTRUM AND COLOR CONDITIONS IN AN
AVERAGE OUTDOOR SCENE AS FUNCTIONS OF GROUND REFLECTANCE
OBJECT ORIENTATION AND VIEWING DIRECTION
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/CHEMICAL COMPOSITION OF SCENT SUBSTANCE CASTOREUM/
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NAVES Y MAZUYER G
NATURAL PERFUME MATERIALS
REINHOLD NY 47

NAYLER W
ACTION OF SALICYLATE,DINITROPHENOL,AND CARDIAC GLYCOSIDES
ON THE ISOLATED TOAD HEART
AUSTRAL J EXP BIOL MED SCI 35 471 57

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AM J PHYS ANTHROPOL 13 386 55

NICOLL G WARNER F
ATMOSPHERIC ATTENUATION MEASUREMENTS AT EIGHT MM WAVELENGTH
TELECOMMUN RES ESTAB, GT BRIT 51

NICHOLLS L
TROPICAL NUTRITION AND DIETETICS
BAILLIERE, TINDALL AND COX, LOND

NICHOLSON E
RAMAN SPECTRA FOR BENZENE WITH CARY SPECTROMETER
ANAL CHEM 32 1634 60

NIESET R PINNEO L BAUS R
THE NEURAL EFFECTS OF MICROWAVE IRRADIATION
ZZBIOPHYSICS LAB, TULANE UNIV
ZZROME AIR DEV CENT
ZZZ AD257198
ANNUAL REPORT RADC-TR-61-65 NOVEMBER 61

NOLTE W
/SMELL CAPACITY IN DUCKS/
ZOOL ANZ 71 115 30

NORINS A
FREE RADICAL FORMATION IN SKIN FOLLOWING EXPOSURE TO
ULTRAVIOLET LIGHT
J INVEST DERMATOL 39 445 62

NORMAN C
SOLAR SIMULATION INSTRUMENTATION
ZZAEROSPACE ENVIR FACIL, ARO, SVERDRUP AND PARCEL
ZZARNOLD ENGNG DEV CENT AF
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NORRIS R
STUDIES IN SEARCH FOR A CONSCIOUS EVADER
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ZZZ AD294832
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NOTTERMAN J MARTIN T
NOTE ON BEHAVIORAL AND PHYSIOLOGICAL INDICES OF STRESS
PSYCHOL REP 4 649 58

NOVARO A
SKIN REACTION TO LONG AND SHORT WAVES
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REVIEW OF SOUND PROPAGATION IN THE LOWER ATMOSPHERE
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OBRIEN B
A STUDY OF NIGHT MYOPIA
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OCONNOR R HOPPOR T
DIFFERENTIATION OF MICROORGANISMS BY INFARED SPECTRA
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FUNDAMENTALS OF ECOLOGY
SAUNDERS, PHILA 59

OESTREICHER H
A THEORY OF THE PROPAGATION OF MECHANICAL VIBRATIONS IN
HUMAN AND ANIMAL TISSUE
ZZAIR MATERIAL COMM, ENG DIV, WPAFB, OHIO
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OGILVIE J C
EFFECT OF AUDITORY FLUTTER ON THE VISUAL CRITICAL FLICKER
FREQUENCY
CANAD J PSYCHOL 10 61 56

OLIPHANT G
DOGS - THE BLOODHOUND
BOOK XX

OLIVER H
SENSE OF SMELL IN THE LION
J BOMBAY NAT HIST SOC 33 977 30

OLSON B
SEALFD CABIN STUDY, WATER SYSTEMS
ZZDOUGLAS AIRCRAFT, MISSILES AND SPACE SYS, STA MON, CAL
61

OMBERG A
ZZZ ATI37653
RADIO COMMUNICATIONS IN JUNGLES
MAY 1 62

ONSTEAD C
MEASUREMENTS OF RADIOACTIVITY IN MAN
ZZARMY MED RES UNIT, EUROPE
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REP NO CSCRD-16 JULY 1 60

OPPEL T HARDY J
STUDIES IN TEMPERATURE SENSATION, I A COMPARISON OF
SENSATION PRODUCED BY INFRARED AND VISIBLE RADIATION
J CLIN INVEST 16 517 37

ORMISTON D FINKELSTEIN B
THE EFFECTS OF CONFINEMENT ON INTELLECTUAL AND PERCEPTUAL
FUNCTIONING
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COUNTERINSURGENCY TRAINING - A SELECTED SUBJECT BIBLIOGRAPHY
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RES MEMO NOV 62A

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COUNTERGUERRILLA OPERATIONS
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RESEARCH MEM NOV 62B

OSBORNE M FINLAYSON L
THE STRUCTURE AND TOPOGRAPHY OF STRETCH RECEPTORS IN
REPRESENTATIVES OF SEVEN ORDERS OF INSECTS
QUART J MICROSCOPIC SCI 103 227 62

OTTOSON D
ANALYSIS OF THE ELECTRICAL ACTIVITY OF THE OLFACTORY
EPITHELIUM
ACTA PHYSIOL SCAND 35 122 56

OTTOSON D
STUDIES ON THE RELATIONSHIP BETWEEN OLFACTORY STIMULATING
EFFECTIVENESS AND PHYSICO CHEMICAL PROPERTIES OF ODOROUS
COMPOUNDS
ACTA PHYSIOL SCAND 43 167 58

OTTOSON D
SOME ASPECTS OF THE FUNCTION OF THE OLFACTORY SYSTEM
PHARMACOL REVS 15 7 63

OUCHAKOFF A
ESSAIS D-APPLICATION PRATIQUE CONCERNANT LA RELATION ENTRA
L-ODORAT ET L-ABSORPTION DES SUBSTANCE ODORANTES
REV DE LARYNGOL 51 77 30A

OUCHAKOFF A
L-ADSORPTION DES SUBSTANCE ODORANTES ET L-ODORAT
ACTA OTOLARYNGOL 14 470 30B

OWEN R
ANATOMY OF VERTEBRATES, VOL 3 /SECTIONS ON HARE AND DEER,
ANIMAL SCENT GLANDS/
XX

OWEN W
CONTACT CHEMORECEPTION IN ADULT MOSQUITOES
J INSECT PHYSIOL 6 13 61

OWEN W B
THE CONTACT CHEMORECEPTOR ORGANS OF THE MOSQUITO AND THEIR
FUNCTION IN FEEDING BEHAVIOR
J INSECT PHYSIOL 9 73 63

OWENS E SHERMAN A
MASS SPECTROGRAPHIC LINES OF THE ELEMENTS
ZZMIT LINCOLN LAB
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TR-265 APRIL 62

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HANDLING AIR CONTAMINANTS RESULTING FROM A CLOSED
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AUTOMATIC SPECTROPHOTOMETRY OF PAPER STRIP CHROMATOGRAMS
ANAL CHEM 24 2019 52

PARKER A
STIMULI INVOLVED IN THE ATTRACTION OF AEDES AEGYPTII TO MAN
BULL ENTOM RES 39 387 48

PARKER G H VAN HEUSEN A
THE RESPONSES OF THE CAT FISH, AMIURUS NEBULOSUS TO METALLIC
AND NON-METALLIC RODS
AMER J PHYSIOL 44 405 17

PARKER R
METHODS OF TISSUE CULTURE
HOEBER [illegible]

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OLFACTORY STIMULI IN MAMMALIAN REPRODUCTION ODOR EXCITES
NEUROHUMORAL RESPONSES AFFECTING OESTRUS PSEUDOPREGNANCY
AND PREGNANCY IN MOUSE
SCIENCE 134 1049 61

PARRY E
THE RAW MATERIALS OF PERFUMERY
PITMAN, ENGLAND 21

PARRY E
PARRYS ENCYCLOPEDIA OF PERFUMERY
CHURCHILL LOND 25

PATHAK J BHATT B
EXCRETION OF SULFUR IN URINE OF INDIANS IN GUJARAT
IND J PHYSIOL PHARMACOL 5 67 61

PATWARDHAN V
NORNAL LEVELS OF URINARY EXCRETION OF ESTROGENS,
PREGNADIOL AND SEVENTEEN KETOSTEROIDS IN ADULTS
IND J MED SCI 11 4 57

PAUKER G
RECENT COMMUNIST TACTICS IN INDONESIA
ZZRAND, SANTA MONICA, CAL
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RM-2619-RC AUG 50

PEAKE W
THE APPARENT TEMPERATURE OF ISOLATED OBJECTS
ZZANTENNA LAB, OHIO STATE U
ZZNASA, WASH DC
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PEARSON O
SCENT GLANDS OF THE SHORT TAILED SHREW
ANAT REC 94 615 46

PECOCK R ED
PRINCIPLES AND PRACTICE OF GAS CHROMATOGRAPHY
WILEY NY 59

PEISS C HERTZMAN A
KINETICS OF EVAPORATIVE WATER LOSS FROM THE SKIN
ZZST LOUIS UNIV FOR WADC
AF TECH REP 6680 PART 5 DEC 51

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PENNER S
QUANTITATIVE MOLECULAR SPECTROSCOPY AND GAS EMISSIVITIES
ADDISON-WESLEY, READING MASS 59

PERYAM D
FOOD ATTITUDES IN AN UNUSUAL ENVIRONMENT
QM FOOD AND CONTAINER INST REP 32-60 OCT 60

PERYAM D
SENSORY DIFFERENCE TESTS /IN FLAVOR RESEARCH AND FOOD
ACCEPTANCE/
ZZARTHUR D LITTLE, CAMBRIDGE
ZZQMR AND EC NATICK
58

PFAFFMANN C
SOMESTHESIS AND THE CHEMICAL SENSES
ANN REV PHYSIOL 2 79 51

PFAFFMANN C
SPECIES DIFFERENCES IN TASTE SENSITIVITY
SCIENCE 117 470 55

PFAFFMANN C
THE SENSE OF TASTE
P 507 IN HANDBOOK OF PHYSIOL 1 NEUROPHYSIOLOGY
AMER PHYSIOL SOC, WASH 59

PFLEIDERER H
SPECTRAL PHOTOMETRIC MEASUREMENTS ON THE HUMAN SKIN IN THE
AREA OF 220-2500 MILLIMICRONS
STRAHLENTHERAPI 117 601 62

PHANSAEKAR S PATWARDHAN V
PARTITION OF URINARY NITROGEN IN INDIAN ADULTS, RELATION
BETWEEN UREA NITROGEN AND TOTAL NITROGEN
INDIAN J MED RES 42 363 54

PHILIP C
TICK TALK

SCI MONTHLY 76 77 53

PHILLIPS G
POSSIBLE APPLICATIONS FOR RESEARCH ON ATMOSPHERIC AIR IONS AT THE BIOLOGICAL LABORATORIES
ZZARMY CHEM CORPS BIOL LABS, FT METRICK
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NITROGEN BALANCE IN NIGERIANS
J TROPICAL MED HYG 62 180 59

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PROCESSING OF SEISMIC DATA FROM AN AUTOMATIC DIGITAL RECORDER
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NRL REP 5456 JAN 60A

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CHEMICAL CONSTITUENTS OF SUBMARINE ATMOSPHERES
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DERMATOL WOCHSCHR 83 1020 26

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THE SONGS OF INSECTS
HARVARD U PRESS, CAMBRIDGE 48

PIERON H
THE SENSATIONS
YALE PRESS, NEW HAVEN 52

PIERSON R FLETCHER A GANTZ E
CATALOG OF INFRARED SPECTRA FOR QUALITATIVE ANALYSIS OF GASES
ANAL CHEM 28 1218 56

PIEZ K MORRIS L
A MODIFIED PROCEDURE FOR THE AUTOMATIC ANALYSIS OF AMINO ACIDS
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SENSORY TESTING METHODS - A MANUAL
ZZQM FOOD AND CONTAIN INST, NATICK

QMFCI REP 25-58 OCT 58

PILGRIM F
SENSORY FACTORS IN FOOD ACCEPTANCE BY MAN
ZZQM RES AND ENG CENT, NATICK
PRES AT AAAS MEETING, DENVER DEC 30 61

PINNEO L
DIRECT CURRENT POTENTIALS OF THE CENTRAL NERVOUS SYSTEM - A REVIEW
ZZBIOPHYS LAB, TULANE U, NEW ORLEANS, LA
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EVAPORATION FROM HUMAN SKIN WITH SWEAT GLANDS INACTIVATED
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BODY COMPOSITION AT SEA LEVEL AND AT HIGH ALTITUDE
J APPL PHYSIOL 16 589 61

PIRON-REATEGUI E
CREATININE EXCRETION AND BODY COMPOSITION
AM J CLIN NUTRIT 10 128 62

PLYLER E DANTI A BLAINE L
VIBRATION-ROTATION STRUCTURE IN ABSORPTION BANDS FOR THE CALIBRATION OF SPECTROMETERS FROM 2 TO 16 MICRONS
J RES NAT BUR STDS 64 JAN R-6164 60

POBINER
INFRARED ABSORPTION SPECTRA FOR CARBOXYLIC ACIDS
ANAL CHEM 35 680 63

POCOCK R
TASTE OR SMELL IN THE LAUGHING JACKASS
NATURE 89 425 12

POCOCK R
ON THE FEET AND GLANDS AND OTHER EXTERNAL CHARACTERS OF THE PARADOXURINE GENERA
ZOOL SOC PROC, LOND, P387 15

POCOCK R
WHITE BOAR SCENT SECRETION
PROC ZOOL SOC LOND 16A

POCOCK R
SCENT GLANDS IN MAMMALS
PROC ZOOL SOC, LOND 16B

PODOLSKY E
RELATION OF THE NOSE TO SEXUAL ACTIVITY

EYE, EAR, NOSE, THROAT MONTHLY 25 193 46

PODOMORDVINOV A
ATTRACTION OF ANOPHELES BY VARIOUS ANIMALS
MEDITS PARAZITOL 11 61 42

POLIAKOFF K
PHYSIOLOGY OF SMELL AND HEARING IN THE TURTLE
RUSS J OF PHYSIOLOGY 13 161 30

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SYMPOSIUM ON NUTRITION IN THE FAR EAST /SEVENTEEN ARTICLES/
METABOLISM 5 203 56

POLLACK L MURPHY T
SAMPLING OF /AIR/ CONDENSATION NUCLEI BY MEANS OF A MOBILE
PHOTOELECTRIC COUNTER
ARCH METRO, WIEN A5 110 52

POPE SCHNEIDER BERNSTEIN
HIGH RESOLUTION NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY
TECHN OF ORGANIC CHEMISTRY, PHYSICAL METHODS VOL 1, PT 4
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MINE DETECTION BASED ON X-RAY FLUORESCENCE TECHNIQUES
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ENGINEER RES AND DEV LABS, FT BELVOIR VA,
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A SURVEY OF MICROWAVE RADIOMETERS WITH TERRAIN MAPPING
APPLICATIONS
ZZAVCO RES AND DEV DIV, WILMINGTON MASS
ZZUSAFBMD
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REP RAD-TR-9-60-20 AUG 60

PORTMAN A
ANIMALS AS SOCIAL BEINGS
NY 61A

PORTMAN A
SENSORY ORGANS SKIN TASTE AND OLFACTION
P37 IN BIOLOGY AND COMPARATIVE PHYSIOL OF BIRDS /MARSHALL A
ED/ VOL 2
ACAD PRESS, NY 61B

POSENER D
MICROWAVE SPECTRUM OF THE WATER MOLECULE
MIT PHYSICS THESIS 53

POSTMUS S VANDERRIJST P
NUTRITION BIBLIOGRAPHY OF INDONESIA
U OF HAWAII PRESS, PACIFIC AREA BIBS FROM FISKETT BIB 55

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PERFUMES, COSMETICS, AND SOAPS /2 VOLS/

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MEASUREMENT OF SPECTRAL AND TOTAL EMITTANCE OF MATERIALS AND SURFACES UNDER SIMULATED SPACE CONDITIONS
REP PWA-1863 JUNE 30 60

PRICE G
WHITE SETTLERS IN THE TROPICS
AMER GEOGRAP SOC, NY PUB 25 39

PROSSER C
COMPARATIVE PHYSIOLOGY OF NERVOUS SYSTEMS AND SENSE ORGANS
ANN REV PHYSIOL 16 103 54

PROSSER C
COMPARATIVE ANIMAL PHYSIOLOGY
SAUNDERS, PHIL 61

PROSTAK A
ATMOSPHERIC TRANSMISSION COEFFICIENTS AND CONSTANTS
PROC OF IRIS /INFRARED SYMPOS, US GOVT/ 5, 3 JULY 60

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FURTHER STUDIES OF THE DIRECTIONAL PROPERTIES OF MAGNETOTELLURIC SIGNALS
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SOME CONTRIBUTIONS OF SMALL MAMMAL BIOCLIMATE STUDIES TO AIR FORCE NEEDS IN NORTHERN REGIONS
ZZARCTIC AEROMED LAB, LADD AFB
ZZZ AD293081
REP TN-56-8 56

PUMPHREY R
HEARING
SYMPOSIA SOC EXP BIOL 50

PURI
SOILS, PHYSICS AND CHEMISTRY
REINHOLD, NY 55

PURNELL J QUINN C
AN APPROACH TO HIGHER SPEEDS IN GAS-LIQUID CHROMATOGRAPHY
P 184 IN GAS CHROMATOG SYMPOS, EDINBURGH 60

PURNELL J
GAS CHROMATOGRAPHY
WILEY, NY 62

PYCRAFT W
CAMOUFLAGE IN NATURE
HUTCHINSON, LOND 25

RAHM U
VARIOUS FACTORS IN THE ATTRACTION OF INSECTS TO MAN
REV SUISSE ZOOL 64 236 57A

RAHM U
ON THE SIGNIFICANCE OF HUMAN ODOR AND SWEAT IN THE ATTRACTION
OF AEDES AEGYPTI MOSQUITOES
ACTA TROP 14 208 57B

RAHM U
THE FUNCTION OF ANTENNAE, PALPAE AND TARSAE OF AEDES EGYPTI
MOSQUITO /IN HOST FINDING BY ODOR/
REV SUISSE ZOOL 63 779 58A

RAHM U
ATTRACTION MECHANISMS RELATING HUMAN ODOR TO AEDES AEGYPTI
MOSQUITOES
Z TROPEN MED U PARASIT 9 146 58B

RAJEWSKY B
ULTRAKURZWELLEN, IN
ERGEBN BIOPHYSIK FORSCH, VOL 1
LEIPZIG 38

RAMACHANDRAN M VENCATACHALAN
URINARY EXCRETIONS OF 17-KETOSTEROIDS IN NORMAL AND
UNDERNOURISHED SUBJECTS
IND J MED RES 44 227 56

RAMAMURTI K
STUDIES ON THE NITROGEN PARTITION IN THE URINE OF
RAJASTHANIS
IND J MED RES 43 61 55

RAMANATHAN N
CHANGES IN THE SALT CONCENTRATION OF SWEAT DURING EXERCISE
IN MONSOON WEATHER
IND J MED RES 44 377 56

RAMANATHAN N CROPALAN C
SOME OBSERVATIONS ON THE CHEMICAL COMPOSITION OF HUMAN
SEBUM
IND J MED RES 46 461 58

RAMANATHAN N
FIELD METHOD FOR THE DETERMINATION OF URINARY CHLORIDE
IND J MED RES 48 103 60

RAMSKILL E
NUCLEAR SUBMARINE HABITABILITY
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SEX ATTRACTION AND RHYTHMIC PERIODICITY IN THE GIANT
SATURNID MOTHS

TRANS ACAD SCI, ST LOUIS 26 82 29

RAY J MARTIN O ALLUISI E
HUMAN PERFORMANCE AS A FUNCTION OF THE WORK-REST CYCLE, A REVIEW OF SELECTED STUDIES
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NAS-NRC PUB 882 OCT 60

REDDLE V
DETERMINATION OF /MICROGRAM/ TRACES OF ORGANIC ACIDS IN SMALL SAMPLES BY CHROMATOGRAPHY
ANAL CHEM 35 853 63

REED M
THE OLFACTORY REACTIONS OF DROSOPHILA MELANOGASTER MEIGEN TO THE PRODUCTS OF FERMENTING BANANA
PHYSIOL ZOOL 11 317 38

REEVES W
QUANTITATIVE FIELD STUDIES ON A CARBON DIOXIDE CHEMOTROPISM OF MOSQUITOES
AM J TROP MED HYG 2 325 53

REGNART H
ON THE LOWER LIMITS OF PERCEPTION OF ELECTRICAL CURRENTS BY FISH
J MAR BIOL ASS U K 17 415 31

REID CD MCALISTER E D
MEASUREMENT OF SPECTRAL EMISSIVITY FROM 2-15 MICRONS
J OPT SOC AMER 49 78 59

REIFFEL L STONE C
NEUTRON ACTIVATION ANALYSIS OF TISSUE MEASUREMENTS OF SODIUM, POTASSIUM AND PHOSPHORUS IN MUSCLE
J LAB CLIN MED 49 286 57

REILLY C
/IONIZATION DETECTORS FOR GAS CHROMATOGRAPHY SENSITIVE TO MICROMICROMOLES/
P 119, GAS CHROMATOGRAPHY DETECTORS IN ADVAN IN ANAL CHEM INSTN INTERSCIENCE, NY 60

REINMUTH W
THEORY OF ELECTRODE PROCESSES
IN ADVANCES IN ANAL CHEM AND INSTRUMENT /REILLY C, ED/
INTERSCIENCE 60

REMINGTON J
PRESSURE-DIAMETER RELATIONS OF THE IN VITRO AORTA
AM J PHYSIOL 203 440 62

RENBOURN E
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PSYCHO-PHYSIOLOGICAL STRESS AND THE SOLDIER
REP NO 118 JUNE 61

RENNER H
THE ORIGIN OF FOOD HABITS
FABER, LOND 44

RIBBANDS C
SCENT PERCEPTION IN THE HONEYBEE
PROC ROY SOC LOND B143 367 55

RICH L INGRAM W BERBER B
A BALANCED ECOLOGICAL SYSTEM FOR SPACE TRAVEL
ZZNEW YORK U COLL ENG
ZZPUBL HEALTH SERVICE, TAFT SANITARY ENG CENT, CINN
61

RICHARDS P
THE TROPICAL RAIN FOREST
CAMBRIDGE U PRESS 52

RICHARDSON E BROWN A
ULTRASONIC PHYSICS
ELSEVIER, NY 62

RICHMOND E
OLFACTORY RESPONSE OF THE JAPANESE BEETLE
PROC ENTOMOL SOC WASH 29 35 27

RIPLEY L HEPBURN G
OLFACTORY ATTRACTANTS FOR MALE FRUIT FLIES
S AFRIC DEPT AGRIC ENTOM MEM 9 3 35

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OBSERVATIONS ON THE NATURAL HISTORY OF THE COMMON MUSK
TURTLE, STERNOTHERUS ODORATUS
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DEODORANTS IN AIR CONDITIONING
TRANS INST OF HEAT AND VENT ENG 27 49 MAY 59

ROBINSON J
/PART PER BILLION DETECTION OF ELEMENTS BY FLAME PHOTOMETRY/
PROGRESS IN NUCLEAR ENERGY 2 232 61

ROBINSON S ROBINSON A
CHEMICAL COMPOSITION OF SWEAT
PHYSIOL REV 34 202 54A
CONTAINS TABLE V

ROBINSON S ROBINSON A
MEASUREMENT OF SWEATING
METHODS IN MED RES 6 100 54B

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HUMAN ACCLIMATIZATION TO COLD
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RODAHL K RENNIE D
COMPARATIVE SWEAT RATES OF ESKIMOS AND CAUCASIANS UNDER
CONTROLLED CONDITIONS

ARCTIC AEROMED LAB REP 7 57B

ROEDER E
INSECT PHYSIOLOGY
WILEY, NY 53

ROEDER K
THE INSECT NERVOUS SYSTEM
ANN REV ENTOMOL 3 1 58

ROEDER K TREAT A
THE DETECTION AND EVASION OF BATS BY MOTHS
AMER SCIENTIST 49 135 61

ROGERS L
THE INFRARED ABSORPTION SPECTRA OF SOME SUGARS AND FURANS
J AM CHEM SOC 60 2619 38

ROGERS T
FACTORS AFFECTING THE WIDTH AND SHAPE OF ATMOSPHERIC
MICROWAVE ABSORPTION LINES
AF CAMBRIDGE RES CENT REP E-5078 51

ROLLINS F
STUDY OF ULTRASONIC TECHNIQUES FOR THE NONDESTRUCTIVE
MEASUREMENT OF RESIDUAL STRESS
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SENSE OF SMELL IN DOGS
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THE INFLUENCE OF SODIUM TRANSPORT ON GLUCOSE TRANSPORT BY AN IN VITRO INTESTINAL PREPARATION
EXPERIENTIA 18 325 62

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THE PHYSIOLOGICAL REQUIREMENTS FOR SURVIVAL RATIONS
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STUDIES ON THE GASEOUS SECRETION OF TRIBOLIUM CONFUSUM DUVAL, THE ODORIFEROUS GLANDS /PART TWO/
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ROTH L NIEGISCH W STAHL W
OCCURRENCE OF TWO-HEXENAL /EMITTED SECRETION/ IN THE COCKROACH EURYCOTIS FLORIDANA
SCIENCE 123 670 56

ROTH L STAY M
THE OCCURRENCE OF PARA-QUINONES IN SOME ARTHROPODS, WITH EMPHASIS ON THE QUINONE SECRETING TRACHEAL GLANDS OF DIPLOPTERA PUNCTATA /BLATTAUA/
J INSECT PHYSIOL 1 305 58

ROTHENBERG H
ULTRASONIC ABSORPTION IN AIR
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ROURKE G
STANDARD VALUES FOR /URINALYSIS/
NEW ENGL J MED 262 84 60

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OLFACTORY NERVE POTENTIALS A DIRECT MEASURE OF CHEMORECEPTION IN INSECTS
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A PHYSICO CHEMICAL TREATMENT OF TASTE THRESHOLDS
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MANAGEMENT
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BIOPHYSICAL CONSIDERATIONS OF LIGHT PROTECTION
J INVEST DERMATOL 39 431 62

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UNIT RESPONSE TO SOUND FROM AUDITORY NERVE OF THE CAT
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RUSSEK M
PARTICIPATION OF HEPATIC GLUCORECEPTORS IN THE CONTROL OF
INTAKE OF FOOD
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FALCONRY,A HANDBOOK FOR HUNTERS
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A LARGE DIAMETER X-RAY SENSITVE CAMERA TUBE
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ELECTROPHYSIOLOGY OF GUSTATORY RECEPTORS IN THE ELECTRICAL
ACTIVITY OF SINGLE CELL
JAP J PHYSIOL 10 620 60

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/AMINO ACIDS AS MOSQUITO ATTRACTANTS
NATURWISS 46 457 59

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SCENT PRODUCING ORGANS OF THE HUMAN BODY
WIEN KLIN WOCHSCHR 50 790 37

SCHEER B
/STUDIES OF THE EMF SOURCE IN ISOLATED FROG SKIN/
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SCHEIDT U REINWEIN H
THE INFRARED SPECTROSCOPY OF AMINO ACIDS
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NASAL FUNCTION AND PSYCHIC ABILITY OF THE DOG
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THE CHEMISTRY OF THE HUMAN SEBACEOUS GLAND
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ELECTROPHYSIOLOGICAL INVESTIGATION ON THE OLFACTORY SPECIFICITY OF SEXUAL ATTRACTING SUBSTANCES IN DIFFERENT SPECIES OF MOTH
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ON ELECTROPHYSIOLOGY OF THE /ISOLATED/ ANTENNA OF THE SILKWORM MOTH ON STIMULATION BY ENRICHED EXTRACT OF THE SEXUAL ATTRACTANT /CYCLOHEPTANONE/
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DOG BREED DIFFERENCES IN LOCATING HIDDEN PERSONS AND ANIMALS
AMER ZOOL 2 446 ABSTR 62

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HEAT REGULATION IN SOME ARCTIC AND TROPICAL MAMMALS AND BIRDS
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SENSE OF SMELL IN THE SHORT TAILED SHREW
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TO ANTIGENS
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HOST FACTORS AND ENVIRONMENT IN STUDIES OF HUMAN SWEAT
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RELATION OF ODOR TO PHYSICOCHEMICAL PROPERTIES OF
COMPOUNDS
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BIOPHYSICS OF DIATHERMY
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ONR
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SINUSFORMIGER WECHSELSTROME
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UBER DIE REIZUNG DER SEHORGANS DURCH DOPPELPHASIGE UNDER
GLEICHGERICHTETE ELEKTRISCHE SCHWINGUNGEN
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DUNKELADAPTATION
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OLFACTORY THRESHOLDS OF HONEYBEES
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ANIMAL ODOURS AND PERFUMES
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EEG CLIN NEUROPHYSIOL 3 427 57

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REFLECTANCE METHODS
METHODS OF BIOCHEM ANALYSIS, VOL TEN XX

SIGGIA STOLTEN
INTRODUCTION TO MODERN ORGANIC ANALYSIS 56
INTERSCIENCE

SIGLING D
/PROBLEM OF BLOODHOUNDS/
TIJDSCHR DIERGENEESK 55 573 28

SIMMONS F
EAT NOT THIS FLESH
U WISCON PRESS, MADISON 61

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STRYCHNINE ON OLFACTORY RECEPTORS IN MAN
ACTA PHYSIOL SCAND 32 252 54

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THE ADULT ANATOMY AND HISTOLOGY OF THE ANAL GLANDS OF THE
RICHARDSON GROUND SQUIRREL /CITELLUS RICHARDSCNII SABINE/
ANAT RECORD 32 1 26

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THE DETECTION OF ODORS AND WATER VAPOR BY GRASSHOPPERS

ORTHOPTERA ACRIDIDAE, AND SOME NEW EVIDENCE CONCERNING
THE SENSE ORGANS WHICH MAY BE INVOLVED
J EXP ZOOL 130 301 55

SLIFER E
CHEMORECEPTORS AND OTHER SENSE ORGANS ON THE ANTENNAL
FLAGELLUM OF THE GRASSHOPPER
J MORPHOL 105 45 59

SLIFER E SEKHON S
THE FINE STRUCTURE OF THE SENSE ORGANS ON THE ANTENNAL
FLAGELLUM OF THE YELLOW FEVER MOSQUITO AEDES AEGYPTI
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SLIFER E SEKHON S
SENSE ORGANS ON THE ANTENNAL FLAGELLUM OF THE SMALL MILKWEED
BUG
J MORPHOL 112 165 63

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SUR LE CHARACTERE DE LA SECRETION DES GLANDES OLFACTIVES DE
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ONE, THE EFFECT OF SKIN TEMPERATURE, TIME AND
MOISTURE ON THE ATTRACTIVENESS OF THE HUMAN HAND
BULL ENT RES 47 89 56

SMITH A
HOUNDS AND DOGS, THEIR CARE TRAINING AND WORKING FOR
HUNTING SHOOTING COURSING HAWKING POLICE PURPOSES
LIPPINCOTT, PHILA 32

SMITH K
INTERMITTENT LOUD NOISE AND MENTAL PERFORMANCE
ZZAVAIL FROM COMM ON HEARING AND BIO-ACOUSTICS, NRC WASH,DC
50

SMITH L
RECENT ADVANCES IN ATMOSPHERIC ELECTRICITY
PERGAMON, LOND 59

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LOND 51

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SNOW W B

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VERHANDL TENTH INTERN CONGR ZOOL, BUDAPEST 1 755 29

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URINARY EXCRETION OF FREE AMINO ACIDS IN NORMAL ADULT MEN AND WOMEN
CLIN CHEM ACTA 4 265 59

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54B

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AN ETHNO-ATLAS
BROWN, DUBUQUE 57

SPERBER I
SECRETION OF ORGANIC ANIONS IN THE FORMATION OF URINE AND BILE
PHARMACOL REV 11 109 59

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AN INVESTIGATION OF PASSIVE RANGING TECHNIQUES FOR MICROWAVE AND SUBMILLIMETER SURVEILLANCE RADIOMETERS
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VARIATIONS IN EXCRETION OF CERTAIN AMINO ACIDS WITH AGE
CLIN CHEM 9 210   63

STANCHO Z
HOUNDS
BOOK PUB HOUSE, BUCHAREST   54

STECHER, ED
MERCK INDEX
MERCK AND CO, RAHWAY, NJ   60

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TARGET SIZE AND VISUAL RECOGNITION
ZZAEROSPACE MED LAB, WRIGHT AIR DEV DIV, WPAFB, OHIO
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THE EFFECTS OF THE INTRODUCTION OF GAS INTO THE COLON
AND ITS PRESSURE AND ACTIVITY
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ALTITUDES
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BLACK, LOND   46

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CANAD J ZOOL 41 577   63

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EXHALED AIR OF DIABETIC PATIENTS
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METHUEN, LOND

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QUANTITATIVE GRAVIMETRIC DETERMINATION OF SEBUM PRODUCTION
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STRAUSS J POCHI P
EFFECT OF ENOVID ON SEBUM PRODUCTION IN FEMALES
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SAUNDERS, PHILA 49

SUSKIND R
THE CHEMISTRY OF THE HUMAN SEBACEOUS GLAND
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LONGEVITY STUDY OF THE EFFECTS OF THREE-CM MICROWAVE RADIATION ON MICE
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62

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THE ELECTRICAL ACTIVITY OF THE OLFACTORY EPITHELIUM STUDIED WITH MICRO AND MACRO ELECTRODES
JAP J PHYSIOL 10 385 60

TAKAGI S SHIBUYA T
STUDIES ON THE POTENTIAL OSCILLATION APPEARING IN THE OLFACTORY EPITHELIUM OF THE TOAD
JAP J PHYSIOL 11 23 61

TAKAKURA T
RADIO NOISE RADIATED ON THE DETONATION OF EXPLOSIVE
A. S. JAPAN 7 210 55

TAKEDA K
THE NATURE OF IMPULSES OF SINGLE TARSAL CHEMORECEPTORS IN THE BUTTERFLY VANESSA INDICA
J CELL COMP PHYSIOL 58 233 61

TAMAR H
TASTE RECEPTION IN THE OPOSSUM AND THE BAT
PHYSIOL ZOOL 34 86

TATEDA H MORITA H
INITIATION OF SPIKE POTENTIALS IN CONTACT CHEMOSENSORY HAIRS OF INSECTS
J CELL COMP PHYSIOL 54 171 59

TAVERNER P
SENSE OF SMELL IN BIRDS
AUK 59 462 42

TAYLOR C L BUETTNER K
INFLUENCE OF EVAPORATIVE FORCES UPON SKIN TEMPERATURE DEPENDENCY OF HUMAN PERSPIRATION
J APPL PHYSIOL 6 113 53A

TAYLOR C BUETTNER K
THE EVAPORATIVE EFFECT ON HUMAN PERSPIRATION
ZZU OF CALIFORNIA, LOS ANGELES
ZZAERO MED LAB, WRIGHT AIR DEV CENT, WPAFB, OHIO
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TAYLOR C W
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TAYLOR J

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ZZDEPT OF THE ARMY
ORO-T-256 DEC 53

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ATMOSPHERIC TRANSMISSION IN THE INFRARED
IN PROC SYMPOSIUM ON IR BACKGROUNDS /CONFIDENTIAL REPORT/
ZZUNIV MICH ENG RES
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2389-2-S 56

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ROLE OF TRICARBOXYLIC ACID CYCLE IN MECHANISMS OF
CHEMORECEPTION
BULL EXP BIOL MED USSR 51 1 61

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TEUBER W
LES AMOURS DES PAPILLONS DE NUIT
INDUSTRIE PARFUM 9 133 54

TFAO B
(ORGANIC COLORIMETRY,LACTIC ACID)
ANAL CHEM 24 722 52

THAYER G
CONCEALING COLORATION IN THE ANIMAL KINGDOM
MACMILLAN NY 18

THEISSING H CAPLAN P
ATMOSPHERIC ATTENUATION OF SOLAR MILLIMETER WAVE RADIATION
J APPL PHYSICS 27 538 56

THOMAS F
REMOVAL OF CARBON MONOXIDE, HYDROGEN AND ORGANIC
CONTAMINANTS
NRL REP 5465 55 APRIL 21 60

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TARGET ACQUISITION FROM THE ARMED HELICOPTER
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THE ATTRACTIVENESS OF HUMAN SWEAT TO MOSQUITOES AND THE ROLE
OF CARBON DIOXIDE
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BIOCHEMICAL DISORDERS IN HUMAN DISEASE
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THOMPSON S P

A PHYSIOLOGICAL EFFECT OF AN ALTERNATING MAGNETIC FIELD
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OLFACTORY CONDITIONING IN A PARASITIC INSECT AND ITS
RELATION TO THE PROBLEM OF HOST SELECTION
PROC ROY SOC B124 56 37

THORPE W
OLFACTORY CONDITIONING IN A PARASITIC INSECT
PARASITIC INSECT
PROC ROY SOC LOND B126 370 38

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OLFACTORY CONDITIONING IN ' PARASITIC INSECT
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SCAND J CLIN AND LAB INVEST 15 167 63

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ODOUR AND CHEMICAL CONSTITUTION
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SOCIAL BEHAVIOR IN ANIMALS
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THE EVOLUTION OF ANIMAL COMMUNICATIONS,A CRITICAL
EXAMINATION OF METHODS
IN EVOLUTIONARY ASPECTS OF ANIMAL COMMUNICATION
SYMPOS ZOOL SOC LOND 8 62

TOBIAS C DUNN R
ANALYSIS OF MICRO-COMPOSITION OF BIOLOGICAL TISSUE BY MEANS
OF INDUCED RADIOACTIVITY
SCIENCE 109 109 49

TOLBECT C STRALTON A TIPTON C
PROPAGATION STUDIES AT 8.6 MM WAVELENGTH ON THREE, FIVE
SEVEN AND TWELVE MILE PATHS
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REP 69 53

TOLLIN G
ELECTRICAL AND MAGNETIC PROPERTIES OF ORGANIC SOLIDS
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TREATT C
CIVET
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AND PERFORMANCE
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PHYSICAL VARIABLES IN THE OLFACTORY STIMULATION PROCESS
J GEN PHYSIOL 46 453 63

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INFARED TECHNIQUES IN IDENTIFICATION AND MEASUREMENT OF
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AM IND HYG ASSOC QUART 13 23 52

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CATALYTIC REACTIVATION OF ACTIVATED CARBON IN AIR
PURIFICATION SYSTEMS
IND ENG CHEM 47 966 55

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THE EFFECTS OF RADAR ON THE HUMAN BODY
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BEHAVIOR UNDER STRESS
ZZDEFENSE RES BOARD, CANADA

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THE STRUCTURE OF POSSIBLE PHOTORECEPTIVE ELEMENTS IN THE SIXTH ABDOMINAL GANGLION OF THE CRAYFISH
J CELL BIOL 15 151 62

UCHIYAMA H KATSUKI Y
RECORDING OF ACTION POTENTIALS FROM THE ANTENNAL NERVE OF LOCUSTS BY MEANS OF MICROELECTRODES
PHYSIOL COMP OECOL 4 154 56

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IN THE AIR RESEARCH AND DEVFLOPMENT COMMAND
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ETHIOPIA, NUTRITION SURVEY
59

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/ACTIVE TRANSPORT OF SODIUM AS A SOURCE OF SHORT CIRCUIT
CURRENT IN FROG SKIN/
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VANDENPUT R
THE CIVET CAT
PERFUM AND ESSEN OIL REC 28 245 37

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GLAND ACTIVITY AND SWEAT COMPOSITION
OXFORD U D PHIL THESIS 49

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A COMPARISON OF ARM BAG SWEAT AND BODY SWEAT
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VACUUM OUTPUT GAS CHROMATOGRAPHY
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VON BUDDENBROCK W
VERGLEICHENDE PHYSIOL VOL 1 SINNESPHYSIOL
BIRKHAUSEN VERLAG, BASEL 52

VONFRISCH K
COMPARATIVE PHYSIOLOGY OF TASTE PARTICULARLY IN HONEY BEES
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TRANSMISSION OF VIBRATORY ENERGY THROUGH HUMAN BODY TISSUE
PROC FIRST NAT BIOPHYS CONF, KM YALE U PRESS 59

VON SKRAMLIK E
ON THE MINIMAL NUMBER OF MOLECULES REQUIRED TO STIMULATE
TASTE AND SMELL SENSF IN MAN
ARCH GES PHYSIOL 249 702 48

VON WITTERN W
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US QUARTERMASTER GEN OFFICE WASH 58

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THE SENSE ORGANS ON THE OVIPOSITOR OF THE BLOWFLY, PHORMIA
REGINA MEIGEN
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ZZZ AD243574
WADD TR 60-243 60
CONTAINS TABLES 5 AND 6

WALTER V J WALTER W G
THE CENTRAL EFFECTS OF RHYTHMIC SENSORY STIMULATION
EEG CLIN NEUROPHYSIOL 1 57 49

WALTER W
SOME EXPERIMENTS ON THE SENSE OF SMELL IN BIRDS STUDIED BY
THE METHOD OF CONDITIONED REFLEXES
ARCH NEERL PHYSIOL 27 1 43

WARD A
THE ENCYCLOPEDIA OF FOOD

PETER SMITH NY 41

WARD S DOUGLASS J
THE RECORDING OF EARTH CURRENTS
ZZSPACE SCI LAB, U OF CALIF, BERKELEY
ZZOFFICE OF NAVAL RESEARCH
ZZZ AD294971
SERIES NO 3 ISSUE NO 28 OCTOBER 62

WARDEN C J WARNER L H
THE SENSORY CAPACITY AND INTELLIGENCE OF DOGS
QUART REV BIOL 3 1 28

WARE F
MEMBRANE POTENTIALS IN NORMAL ISOLATED PERFUSED FROG
HEARTS
AM J PHYSIOL 190 194 57

WARE F
EFFECTS OF CALCIUM DEFICIENCY ON CELL MEMBRANE POTENTIAL
OF ISOLATED FROG HEARTS
AM J PHYSIOL 198 547 60

WARING C, ED
TRANSMISSION AND RECEPTION OF SOUNDS UNDER COMBAT
CONDITIONS
SUMMARY TECH REP OF DIV 17, NDRC, VOL 3 46

WATANABE K ZELIKOFF M
ABSORPTION COEFFICIENTS OF WATER VAPOR IN THE VACUUM
ULTRAVIOLET
J OPT SOC AMER 43 753 53A

WATANABE K ZELIKOFF M INN E
ABSORPTION COEFFICIENTS OF SEVERAL ATMOSPHERIC GASES
ZZAF CAMBRIDGE RES CENTER
GEOPHYS RES PAPERS 21 53B

WATKINS W
EFFECTS OF CERTAIN NOISFS UPON DETECTION OF VISUAL SIGNALS
ZZU OF TEXAS, AUSTIN, TEXAS
ZZZ AD294582
PHD DISSERTATION JANUARY 63

WATSON C
(FAT CONTENT OF FECES)
ARCH INT MED 59 196 37

WATTS H
HOUND AND QUARRY
ROUTLEDGE 53

WEBB H BROWN F BRETT W
EFFECTS OF IMPOSED ELECTROSTATIC FIELD ON RATE OF LOCOMOTION
IN ILYANASSA
BIOL BULL 118 367 60

WEBER D
SPECTRAL EMISSIVITY OF SOLIDS IN THE INFARED AT LOW
TEMPERATURES
J OPT SOC AMER 49 815 59

WEDDELL G PALMER E PALLIE W
NERVE ENDINGS IN MAMMALIAN SKIN - A REVIEW
BIOL REV 30 159 55

WEINER J LEIKIND M GIBSON J
VISIBILITY - A BIBLIOGRAPHY
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ZZZ AD10557
JULY 52A

WEINER J S
A SPECTROPHOTOMETER FOR MEASUREMENT OF SKIN COLOR
MAN 1 253 52B

WEINER J VAN HEYNINGEN R
RELATION OF SKIN TEMPERATURE TO SALT CONCENTRATION OF
GENERAL BODY SWEAT
J APPL PHYSIOL 4 725 52

WEISBERGER A
PHYSICAL TECHNIQUES IN ORGANIC CHEMISTRY
MULTIVOLUME BOOKSET

WEISENBERGER E
TEN MICROMICROGRAM SENSITIVITY BY ELECTRODEPOSITION ANALYSIS
FOR COPPER
MIKROCHIM ACTA PAGE 946 60

WEISSLER G
QUANTITATIVE MEASUREMENTS OF RADIATION OF THE EXTREME
ULTRAVIOLET
ZZDEPT OF PHYSICS, U OF SOUTHERN CAL, LA
ZZARMY OFFICE OF ORDNANCE RES
ZZZ AD295132
NOV 30 62

WEISZ A LICKLIDER J SWETS J
HUMAN PATTERN RECOGNITION PROCEDURES AS RELATED TO
MILITARY RECOGNITION PROBLEMS
ZZBOLT BERANEK AND NEWMAN, CAMBRIDGE MASS
ZZELECTRONICS RES DIR, AF CAMB RES LAB, BEDFORD MASS
ZZZ AD278540
AFCRL-62-387 JUNE 15 62

WELCHER F
STANDARD METHODS FOR CHEMICAL ANALYSIS
VAN NOSTRAND NY 63

WELKOWITZ W
MECHANICAL MECHANISM OF DESTRUCTIVE EFFECTS OF SOUND ON
TISSUE
J ACOUST SOC AMER 27 1142 55

WELLS W MAKITA M
THE QUANTITATIVE ANALYSIS OF FAECAL NEUTRAL STEROLS BY
GAS-LIQUID CHROMATOGRAPHY
ANALYT BIOCHEM 4 204 62

WENZEL B
TECHNIQUES IN OLFACTOMETRY A CRITICAL REVIEW OF THE

LAST ONE HUNDRED YEARS
PSYCHOL BULL 45 231 48

WENZEL B
PRACTICAL APPLICATIONS OF OLFACTOMETRY
PROC SCI SECT TOILET GOODS ASS 14 11 50

WENZEL B
THE CHEMICAL SENSES
ANN REV PSYCHOL 5 111 54

WESCOTT J KUSHNER S
ACOUSTIC BACKGROUND AT THE EARTHS SURFACE
ZZACOUST AND SEISMIC LAB, INST OF SCI AND TECH, U OF MICH
ZZARMY SIGNAL MISSILE SUPPORT AGENCY, WHITE SANDS
ZZZ AD297481
FINAL REPORT FEB 63

WEYBREW B
BIBLIOGRAPHY OF SENSORY DEPRIVATION ISOLATION AND CONFINEMENT
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ZZZ AD234102
MEM REP NO 60-1 JAN 60

WHARTON D
THE ODOROUS ATTRACTANT OF THE COCKROACH PERIPLANETA
AMERICANA
J GEN PHYSIOL 37 461 61A

WHARTON D R WHARTON M L
EFFECTS OF RADIATION ON NITROGEN AND PHOSPHORUS EXCRETION BY
THE COCKROACH, PERIPLANETA AMERICANA, L
RADIATION RESEARCH 14 432 61B

WHARTON M WHARTON D
THE PRODUCTION OF SEX ATTRACTANT SUBSTANCE AND OF OOTHECAE
BY THE NORMAL AND IRRADIATED AMERICAN COCKROACH
PERIPLANETA AMERICANA L
J INSECT PHYSIOL 1 229 57

WHEATLEY V
THE ESTIMATION OF SQUALENE IN SEBUM AND SEBUM LIKE MATERIALS
BIOCHEM J 55 637 53

WHEATLEY V
SEBUM,ITS CHEMISTRY AND BIOCHEMISTRY
AMER PERFUM AROM 68 37 56

WHEATON J
FACT AND FANCY IN SENSORY DEPRIVATION STUDIES
ZZDEPT NEUROPSYCH, AIR UNIV, BROOKS AFB TEX
ZZZ 226325
REVIEW 5-59 AUGUST 59

WHEATON R
HUMAN WASTES IN A SIMULATED MANNED SPACE CRAFT
IN /BIOLOGISTICS FOR SPACE SYSTEMS/
ZZAEROSPACE MED LAB WADD DAYTON
AMRL-TDR-62-116 62

WHITCOMB M

BIBLIOGRAPHY OF REPORTS ACQUIRED BY CHABA
ZZCOMM ON HEARING AND BIO-ACOUSTICS, WASH, DC
JANUARY 63

WHITE P
CULTIVATION OF ANIMAL AND PLANT CELL
RONALD PRESS, NY 61

WHITEHAIR L MATSUMURA K
THE INFLUENCE OF DIET ON VOLUME AND MAJOR MOLECULAR
COMPOSITION OF GASTROINTESTINAL GAS IN RATS
ZZARMED FORCES FOOD AND CONTAIN INST, NATICK, MASS
ZZZ AD292637
INTERIM REP, AMXFC REP NO 38-62 NOVEMBER 62

WHITNEY L
DOGS AND KENNEL SCIENCE
KENNEL SCI PUBL CO NEW HAVEN 33

WHITNEY L
BLOODHOUNDS
WHITNEY NY 47

WHITNEY L
BLOODHOUNDS
JUDD PUBL CO NY 55

WIGGLESWORTH V
PRINCIPLES OF INSECT PHYSIOLOGY
METHUEN, LOND 53

WILLIAMS C LEONARD R
MICROANALYTICAL DETERMINATIONS OF DIHYDROXY AROMATIC ACID BY
GAS CHROMATOGRAPHY
ANALYT BIOCHEM 5 362 63

WILLIAMS C SWEELEY C
A NEW METHOD FOR THE DETERMINATION OF URINARY AROMATIC
ACIDS BY GAS CHROMATOGRAPHY
J CLIN ENDOCRIN 21 1500 61

WILLIAMS D SMITH S
THE DETERMINATION OF MICROGRAM QUANTITIES OF
MONOETHANOLAMINE AND AMMONIA IN AIR
ZZNAV RES LAB WASH
NRL MEMO REP 898 59

WILLIAMS H
IMPAIRED PERFORMANCE WITH ACUTE SLEEP LOSS
PSYCHOL MONOGR 73 NO 14 59

WILLIAMS R
QUANTITATIVE DETERMINATION OF ORGANIC STRUCTURES BY NUCLEAR
MAGNETIC RESONANCE,INTENSITY MEASUREMENTS
ANN NY ACAD SCI 70 890 58

WILLIAMS R
DETOXICATION MECHANISMS, METABOLISM AND DETOXICATION OF
DRUGS, TOXIC SUBSTANCES AND OTHER ORGANIC COMPOUNDS
CHAPMAN AND HALL, LOND 59A

WILLIAMS R
NUCLEAR MAGNETIC RESONANCE IN PETROLEUM ANALYTICAL RESEARCH
SPECTROCHIM ACTA 14 24 59B

WILLIAMS R
DETOXICATION MECHANISMS /DRUGS/
CHAPMAN AND HALL, LOND 59C

WILLIAMSON A ZAMENHOF S
DETECTION AND RAPID DIFFERENTIATION OF GLUCOSAMINE AND GALACTOSAMINE,GLUCOSAMINE-URONIC ACID AND GALACTOSAMINE-URONIC ACID
ANAL BIOCHEM 5 47 63

WILLIS E
OLFACTORY RESPONSES OF FEMALE MOSQUITOES
J ECON ENTOMOL 40 769 47

WILLIS E
OLFACTORY RESPONSES OF FEMALE MOSQUITOES- RESPONSES OF AEDES AEGYPTI AND ANOPHELES QUADRIMACULATUS TO HUMAN ODOR AND TO CO2 IN AN OLFACTOMETER
OHIO STATE U - ABSTRACTS OF DOCTORAL DISSERTATIONS
54 395 48

WILSON E DURLACH N ROTH L
CHEMICAL RELEASERS OF NECROPHORIC BEHAVIOR IN ANTS
PSYCHE 65 108 58

WILSON E PAVAN M
GLANDULAR SOURCES AND SPECIFICITY OF SOME CHEMICAL RELEASERS OF SOCIAL BEHAVIOR IN DOLICHODERINE ANTS
PSYCHE 66 70 59

WILSON E
CHEMICAL COMMUNICATIONS AMONG WORKERS OF THE FIRE ANT SOLENOPSIS SAEVISSIMA
ANIM BEHAV 10 134 62

WILSON W
PULSED AND MODULATED ULTRAVIOLET AND INFRARED SYSTEMS
ZZZ AD320189
MAY 31 60

WING J TOUCHSTONE R
A BIBLIOGRAPHY OF THE EFFECTS OF TEMPERATURE ON HUMAN PERFORMANCE
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THE HISTOCHEMISTRY AND MORPHOLOGY OF THE CUTANEOUS SENSORY END-ORGANS OF THE CHICKEN
J COMPAR NEUROL 117 27 61

WINSTON P W
POSSIBLE HUMIDITY RECEPTOR MECHANISM IN THE CLOVER MITE
J INSECT PHYSIOL 9 89 62

WITHEY S
REACTION TO UNCERTAIN THREAT

ZZSURVEY RES CENT, U OF MICH, LANSING
APRIL 56

WITKIN H WAPNER S LEVENTHAL T
SOUND LOCALIZATION WITH CONFLICTING VISUAL AND AUDITORY CUES
J EXP PSYCHOL 43 58 52

WITTFOGEL K
FOOD SCIENCE IN CHINA AND INDIA
P 61 IN HUMAN NUTRITION, HISTORIC AND SCIENTIFIC /GALDSTON/

WOLBARSHT M
WATER TASTE IN PHORMIA
SCIENCE 125 1248 57

WOLBARSHT M
ELECTRICAL ACTIVITY IN THE CHEMORECEPTORS OF THE BLOWFLY
J GEN PHYSIOL 42 393 XX

WOLBARSHT M HANSON F
DENDRITIC ACTION POTENTIALS IN BIPOLAR CHEMORECEPTORS
ABSTR 11 ANN MTG BIOPHYS SOC, NYC ITEM WF 5 63

WOLF A
THIRST
THOMAS, SPRINGFIELD 58

WOLF E
ULTRAVIOLET TRANSMITTER DESIGN AND DEVELOPMENT PROGRAM
ZZSYLVANIA ELECTRONIC SYST CENT, BUFFALO NY
ZZCMMUN LAB, AERONAUT SYS DIV, WP-AFB OHIO
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WOLKEN J
PHOTORECEPTOR STRUCTURES IN BIOLOGICAL SYSTEMS
INT REV CYTOL 2 195 61

WOLOCHOW H
DETECTION OF AIRBORNE MICROORGANISMS THROUGH THEIR UNIQUE
COMPOUNDS
ZZNAVAL BIO LAB, U CAL, BERKELEY, CALIF
ZZBUREAU OF YARDS AND DOCKS, OFF OF NAVAL RES
ZZZ AD211120
JANUARY 15 59

WOOD C FYDE M, EDS
THE ART OF FALCONRY /OF FRIEDRICH 2, EMPEROR OF GERMANY/
BRANFORD, BOSTON 55

WOOD W DEEM H
METHODS OF MEASURING EMITTANCE
ZZDEFENSE METALS INFO CENT, BATTELLE MEMORIAL INST, COLUMBUS
ZZZ AD248977
DMIC MEMO 78 DEC 27 60

WOOD W SNELL J
QUANTITATIVE SYSTEM FOR CLASSIFYING LANDFORMS
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TECH REP EP-124 FEB 61

WOOD W DEEM H LUCKS C
THERMAL RADIATIVE PROPERTIES OF SELECTED MATERIALS
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METHODS FOR TESTING BEE ATTRACTANTS
BULL ENTOM SOC AMER 4 91 58

WORTH R
RURAL HEALTH IN CHINA FROM VILLAGE TO COMMUNE
AM J HYGIENE 77 228 63

WORTHING A
TEMPERATURE RADIATION EMISSIVITIES AND EMITTANCES
J APPL PHYSIOL 11 421 40

WRIGHT TELKES M
/REFLECTING POWER OF WHITE AND NEGRO SKIN/
PROC AM PHYSIOL SOC MARCH 30 34

WRIGHT M
WRIGHT
THE INFRARED ABSORPTION SPECTRA OF THE STEREOISOMERS OF CYSTINE
J BIOL CHEM 120 641 37

PERSISTENCE OF TASTE ORGANS IN TONGUE TRANSPLANTS OF TRITURUS V
J EXP ZOOL 129 357 55

WRIGHT R MICHELS K
HUMAN PROCESSING OF OLFACTORY INFORMATION
PRESENTED AT THIRD BIONICS SYMPOSIUM, DAYTON MARCH 63

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A STUDY FOR MATERIALS FOR INFRARED RADIATION DETECTORS
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VISION IN MILITARY AVIATION
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THE INFRARED ABSORPTION OF WATER VAPOR
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FINAL REP VOL 2 SSD-TDR-62-127 SEPT 62

WYNNE-EDWARDS V
ANIMAL DISPERSION IN RELATION TO SOCIAL BEHAVIOR
HAFNER, NY 62

YAMAMOTO Y
QUANTITATIVE CORRELATION ON THE BASES IN URINE
FUKUSHIMA MED J 9 601 59

YAMASHITA S
STIMULATING EFFECTIVENESS OF CATIONS AND ANIONS AS CHEMORECEPTORS IN THE FROG
JAP J PHYSIOL 13 54 63

YAROSLOWSKI N STANEWICK A
ABSORPTION OF HUMID AIR IN THE FORTY TO TWO THOUSAND MICRON REGION
OPTICS AND SPECTROS 6 799 59

YATES H
TOTAL TRANSMISSION OF THE ATMOSPHERE IN THE INFRARED
ZZNAVAL RES LAB, WASH
NRL 3858 SEPT 10 51

YOSHIMI T
THE DIURNAL RHYTHM OF SALT EXCRETION
J PHYSIOL SOC, JAPAN 21 981 59

YUNKER W
PURE ROTATIONAL SPECTRUM OF WATER VAPOR 1 TABLE OF LINE PARAMETERS
ZZWHITE SANDS MISSILE RANGE, N M
ZZZ AD298151
ERDA-2 FEBRUARY 63

ZAHN W
/OLFACTORY SENSE OF CERTAIN BIRDS/
Z VERGLEICH PHYSIOL 19 785 33

ZEFF J BAMBENEK
DEVELOPMENT OF A UNIT FOR RECOVERY OF WATER AND DISPOSAL
OR STORAGE OF SOLIDS FROM HUMAN WASTES - PART 1- THE
STUDY PHASE
ZZAMER MACHINE AND FOUNDRY, MECHANICS RES DIV
ZZAEROSPACE MED LAB, WRIGHT AIR DEV CENT, WPAFB, OHIO
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ZIMMER H MELTZER M
AN ANNOTATED BIBLIOGRAPHY OF LITERATURE RELEVANT TO THE
INTERROGATION PROCESS
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ZOTTERMAN Y
THE NERVOUS MECHANISM OF TASTE
ANN NY ACAD SCI 81 358 59